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This a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by disclosing interesting information well in advance of the usual scientific publications.

The articles are written primarily by members of the staff of ONRL, with certain articles prepared by, or in cooperation with, members of the scientific

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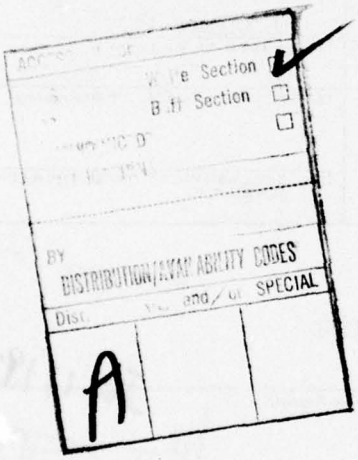

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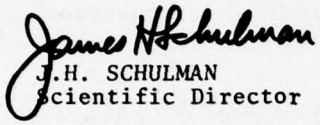

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AEROSPACE

ICH BIN EIN ATMOSPHARISCHER ELEKTRIKER

I have recently completed my third European "sabbatical" in the upper-atmosphere field and wish to report on some trends I have observed over this 15-year period, which encompasses the rapid expansion and subsequent maturity of the general field of "space research."

My first visit, in 1962, was with the University College London group that later became the nucleus of the Mullard Space Science Laboratory. As I had participated in early satellite programs at Los Alamos I was given an imposing title and a then princely stipend [£1600 ($4500) p.a.]. The UCL group had fine sounding-rocket programs in both aeronomical and astronautical science, but had already made the decision, along with other groups, that this was the time to use sounding-rocket programs as a stepping stone to the satellite programs that were available from NASA and, it appeared at the time, from the European Space Research Organization. This approach ultimately led many groups to decide in favor of astronomical over aeronomical science, and caused a number of individual scientists to change the direction of their careers. This explains why, I think, we were caught short when upper-atmosphere data were needed to evaluate the suggested threat to atmospheric ozone by the SST.

I was perversely moving in the opposite direction and have been moving downward (in the atmosphere, at least) ever since. I like to think that this was due to a natural development of interests, but maybe I was influenced by a disinclination to spend four days a week on airplanes and by my US university's showing less inclination than similar European groups to free its faculty from other academic duties to participate in space "spectaculars." As a result I stayed in sounding rockets and spent my next sabbatical in 1969 with Marcel Nicolet's Institute for Space Aeronomy in Brussels. This group had largely stuck to atmospheric chemistry and spectroscopy while many other groups were engaging in more space-oriented programs. When the crunch came in science in the US in the next few years, this Belgian group and others in Europe continued with relatively little interruption to work in upper-atmosphere science and provided many valuable data for the US CIAP program of 1972-75, which was established to provide an interim evaluation of damage to the ozone layer.

My own research has recently led me to the conclusion that there is more going on in the upper atmosphere than is generally reported in the current literature. Specifically, I have come to believe that electric fields related to geomagnetic activity can control the flow of particulates (probably cosmic dust) down through the earth's atmosphere and may provide a solar-terrestrial coupling mechanism as well as a means of scavenging pollutants in the stratosphere. Much of the research supportive of or related to this viewpoint is being done in Germany; so it would have been logical to spend my third sabbatical there, or in Brussels where I continue to collaborate with the IAS on relatively conventional aeronomical topics. However, for financial reasons, Belgium and Germany seemed out of the question with a family.

The solution was the kind offer of a desk from the US Army Research and Standardization Group's European office in London, allowing relatively easy access to Northern Europe. (The UK, along with a few Southern European countries, is still just possible for a sabbatical without supplemental income.) The USARSG, to their credit, in my view, maintains close relations with the German groups that are doing work in which I am interested, and I was privileged to visit several of these groups under USARSG auspices.

R. Reiter's group in Garmisch-Partenkirchen has instrumented the Zugspitze area (*ESN* 31-1:11) and has observed enhanced vertical electric fields and radio-nuclides ejected from the stratosphere in the days following geomagnetic storms. R. Mühleisen, who is a professor at Tübingen but whose Institute is in Ravensburg, has observed this sort of field enhancement from balloons, and believes the magnitude is too great to be explained by the "mapping" of ionospheric fields to low altitudes (the Mozer mechanism) but must require

another generator mechanism. The only groups to have measured mesospheric (~50-80 km) electric fields are in the USSR, and they claim to have consistently observed several volts/meter, which is totally different from the conventional picture.

Hans Widdel and colleagues at the Max-Planck Institute for Aeronomy at Lindau-Harz were the first to observe very low-mobility ions in the mesosphere, confirming the existence of a high density of particulates. They have continued with active participation in sounding-rocket programs through the "winter anomaly" campaign of January 1976 (*ESN* 31-1:11), but it appears that they are faced with a lack of support to continue their work.

I received the general impression that all over Europe a change in direction is developing because of the opportunities created by Spacelab, and many groups are abandoning other programs to stay involved in Spacelab. Since this is also true in the US, I think that a rather unbalanced situation is developing. For example, a program at Birmingham University to measure electric fields on rockets was recently dropped in order to stay in satellite x-ray astronomy. It is possible that this situation is not worldwide, however; as far as I know, electric fields continue to be measured in Novosibirsk.

This situation is not alarming if the view that the atmosphere can be more effectively studied entirely from satellites is correct. Its accuracy depends on the dominant effects in chemistry and dynamics being sensed remotely. My own research and conversations with the groups mentioned above lead me to believe that many of the relevant processes fall in the realm of "atmospheric electricity," a field in which German groups have historically been strong, with other good work being done in Sweden, France, and the UK. It is difficult to see how many of the important electrical parameters can be studied by other than *in situ* means. Since some of us believe the mesosphere, that last frontier too high for balloons and too low for satellites, to be crucial to coupling processes between higher and lower regions, we view the general decline of sounding-rocket programs with trepidation. (Leslie C. Hale, Pennsylvania State Univ.)

COMPUTER SCIENCE

HELP FOR THE HANDICAPPED

In the Department of Engineering (and the Department of Psychology) of Warwick University on the southern edge of the city of Coventry (Warwickshire, England CV4 7AL), senior research fellow Dr. J.M. Gill, along with two secretaries and an occasional research student, constitutes the entire staff of the Warwick Research Unit for the Blind. The output of this Unit, however, would do credit to a team several times as large. Gill, who enrolled in the University when it opened in October 1966 and was the first person to get three degrees there (1969, 1971, and 1973), did his doctoral work on the design, production, and evaluation of tactual maps for the blind. Such maps are embossed together with Braille labels on sheets of plastic of about the same size as this page but a little thicker. Ridges of different heights may represent the external and internal walls of a building (e.g., Euston Station), and rough ridges may designate particular facilities, such as ticket windows. Pillars and doors are also shown.

Gill emphasizes that most of the blind have lost their sight at advanced ages, that most have not lost it entirely, and that only a small proportion read Braille. The main emphasis of the Unit's work, nonetheless, has been on aids for the totally blind, especially the automated production of Braille materials. Gill points out that aids for the visually handicapped are applicable not only to the problems posed by disease, trauma, and congenital disorders but also to the disabilities imposed by an adverse environment such as that encountered by deep-sea divers, who have difficulty in seeing and even in moving their limbs as well as in feeling with their fingers. (Indeed, the blindness caused by diabetes is often accompanied by a diminution of the sense of touch.)

While, in the US, closed-circuit television has found considerable use

among the partially sighted for enlarging print and increasing or even reversing the contrast (turning print into white on black), there is less readiness in Britain to employ such gadgets; instead, stress is laid on the printing of books in clear type, large type, or even with white print on black paper. Gill's Unit, however, has produced some very useful and relatively inexpensive devices and is promoting their manufacture elsewhere.

One of these gadgets, not much larger than a match box, serves to enable a blind person to return to any desired location. He switches it on and leaves it there. When he returns to within earshot of that place, he claps his hands, and the device responds with a 2-sec beep. It is powered by a 9-volt battery, which Gill found to be the kind most available throughout the world, and its sensitivity is controlled by an internal adjustment. He expects it to be sold for $6. Another device being developed for manufacture is an electric clock with a bar on top which, when pressed, causes the clock to emit three series of beeps—the first tolling the hour, the second the number of tens of minutes, and the third the number of additional minutes. The Unit has also been involved in the development of Braille readouts for calculators and in providing tactual musical scores as well as tactual maps [*Electronics and Power* 19(14), 331-332 (August 1973)].

Gill provided a thorough tactual mapping of the town of Kenilworth just south of Coventry in order to be able to determine the usefulness of such maps for the blind (who constitute only the usual proportion of the town's 20,000 inhabitants). He found that they have continued to carry the maps with them for years. The utility of tactual maps and, indeed, the ability of the blind to travel without the help of others would be much enhanced, however, if a compass were available that could be read by the blind. Gill indicated, however, that the problem of their reading the pointers on meters has not yet been satisfactorily solved and that the blind also have difficulty in holding a compass sufficiently horizontal for its needle to swing freely, especially when they are standing on an inclined surface.

Gill's Unit has two high-speed Braille embossers and is getting a third. Under the control of a time-shared computer, they produce 3 lines/sec of 40 characters each by embossing up to 80 dots per line 9 times per second to form the 2-dot-wide by 3-dot-high Braille cells. The computer is fed tapes carrying, among other things, *INSPEC* and *Psychological Abstracts*; 50,000 lines of Braille abstracts per month are produced for the benefit of blind psychologists and for the evaluation of this system of automatic transcription.

The American Psychological Association sends its tapes of *Abstracts* over to Coventry, where they are processed on an American computer, embossed on an American output device, and 96% of the output is air-mailed back to North America. Some care is exercised to ensure that American readers can understand the British dialect, since American Braille uses capital and lower-case letters, while British does not; and different Braille contractions are preferred in the two countries; e.g., dear is divided into d-ea-r in the US and into d-e-ar in the UK, while other English-speaking countries prefer other variants. In order to provide privacy for blind depositors in Britain, Gill's Unit is processing tapes from Lloyds Bank Limited, which is thus able to send out over 4000 Braille checking-account statements per year at no extra charge.

Perhaps the greatest impact of Gill's Unit, however, comes from its *International Register of Research on Blindness and Visual Impairment*, which is supported by the American Foundation for the Blind. The first edition of this *Register* appeared in 1975, and the second is to be published in October or November 1977 in inkprint and in grade-1 and grade-2 Braille from the same computerized database. The first section of the *Register* will contain the names, addresses, and brief descriptions of projects of those working on nonmedical research for the blind and the visually impaired, including teaching and rehabilitation techniques as well as devices. The second section will contain brief details on the main organizations of and for the blind throughout the world, and the third section will

describe periodicals that sometimes report relevant research. The purpose of the *Register* is to facilitate contact between people in different places working on similar problems; Gill has on occasion found as many as five different groups in the same university working to aid the blind, each one aware of no more than one or two of the others. He is eager to hear from anyone doing research to overcome visual handicaps that may be added to the listing in his *Register*.

Gill's database includes information about language proficiencies, which is helpful in organizing conferences. He finds English to be the most useful language for this purpose; the addition of simultaneous French would hardly increase the accessible audience at all, but German is the next most useful language, and after it Polish. Gill travels widely throughout the world, tracking down work in his field, and he has found some very good research underway in Poland, the USSR, and Bulgaria as well as elsewhere. He understandably has no time for teaching, but he occasionally supervises students' senior projects. He is also the editor of the *Braille Automation Newsletter*, a quarterly published in collaboration with the American Foundation for the Blind for those working on the computer-assisted production of Braille.

Another current project is the provision of a Braille strip output for Viewdata (*ESN* 31-2:72) to enable a stockbroker, for example, who has lost his sight to carry on with his occupation. Finally, a computer-assisted system for transcribing short documents into Braille has been developed and is being evaluated with a significant sample of potential users. So far over a million words have been transcribed as part of this evaluation program.

In addition to support from the American Foundation for the Blind and Lloyds Bank, Gill has subventions (at least till December) from the Department of Health and Social Security (UK), the Ford of Britain Trust, the Royal National Institute for the Blind, and the Surrey Voluntary Association for the Blind, but unfortunately he finds it necessary to spend nearly half of his time seeking funding. Additional support would enable Gill to augment his staff and produce very useful results like the foregoing at an even greater rate. This work has an advantage over some other work in that it is being tested on the sort of people it's intended to benefit.
(Nelson M. Blachman)

INSTITUT DE RECHERCHE D'INFORMATIQUE ET D'AUTOMATIQUE

The Institut de Recherche d'Informatique et d'Automatique (IRIA), Rocquenurent (Paris), France, constitutes a unique development for applied mathematics and computer science. IRIA was founded eight years ago by a small group under the leadership of J.L. Lions, with the primary aim of developing new mathematical methods for answering questions arising in new technologies. From the beginning, it was envisaged that many of these questions could best be answered by appropriate numerical computations.

The systematic efforts made by scientists at IRIA to find new mathematical problems arising in French industry have been very productive; many such problems have been solved by a variety of finite-element methods. Besides a typical mix of problems from solid mechanics, a variety of transonic-flow and magnetic-field problems have been solved in two and three space dimensions. A sustained effort is currently being made to construct codes for solving the Navier-Stokes equations and to treat composite media with periodic structure.

Among the active members of IRIA may be mentioned R. Glowinski, A. Marrocco, O. Piranneau, and M.P. Schütenberger. In addition, IRIA maintains fruitful collaboration with many outside groups: New York University, the University of Pavia (E. Magenes), Novosibirsk (G. Marchuk), and the Hebrew University in Jerusalem, to mention a few. Thus the transonic-flow codes constructed at IRIA took the NYU codes of Garabedian and Jameson as their starting point. Within France, Messrs. Feingold, Raviart, Temam, and Ciarlet provide links with Electricité de France and leading universities.

CYCLADES. IRIA is trying to develop a nationwide computer network called CYCLADES, comparable with the ARPA network in the United States. Participating government agencies include the Ministries of Meteorology, Transport, and Defense; the participating universities include Grenoble, Lyon, Rennes, and Toulouse. It is at present an operational pilot project, designed to carry out real-world experiments concerning the use of generalized computer networks.

MODULEF. An important new development being initiated and coordinated by IRIA is the international Club MODULEF. This is a large group of mathematicians collaborating formally in the development of a computer-program library for finite-element computations. The Club MODULEF will cooperate in this area by procedures similar to those adopted by the British Numerical Algorithms Group (NAG). (For more on NAG, see W.J. Gordon, *ESN* 31-2:54.)

In detail, the Club includes: (i) a Directing Committee, an Executive Committee, and Adherents. The current Directing Committee consists of Messrs. Absi, Breton, Canevet, Cea, Feingold, Malavard, Poccard, Raviart, Voillon, Perronet (Secretary), and Glowinski (Chairman). This Committee will make all urgent decisions and will call a general meeting of all club members at least once a year. Under the leadership of the Secretary of the Directing Committee, the Executive Committee will implement all decisions, and will be responsible for coordinating programs and disseminating documentation.

Each member retains ownership of all the subprograms that he (or she) develops, but all members can use all subprograms (modules). These modules, written in FORTRAN, will be distributed annually on magnetic tape. Brochures will also be distributed every three to four months describing: (a) new library acquisitions, (b) changes in modules previously distributed, and (c) a list of modules under active development. The resulting MODULEF Subroutine Library promises to be a valuable supplement to such existing libraries maintained by IMSL in the US and NAG in Britain, as well as the Argonne Code Library maintained for ERDA, and IBM's SSP and SL-MATH Libraries.
(Garrett Birkhoff, Dept. of Mathematics, Harvard Univ., Cambridge, MA)

EARTH SCIENCES

THE INTERNATIONAL METEOROLOGICAL INSTITUTE AND THE METEOROLOGY DEPARTMENT, STOCKHOLM

The International Meteorological Institute (IMI), in Stockholm, was created in 1955 by the Swedish Parliament with the objective of "conducting research in meteorology and associated fields and promoting international scientific cooperation within meteorology." C.G. Rossby, the father of dynamic meteorology, had a great deal to do with the creation of the IMI when, in 1947, he returned to Sweden, his native country, after spending a number of years in the US starting this relatively new field. Since the foundation of the IMI, the professor of meteorology at the University of Stockholm has also been the Director of the Institute. This position is currently filled by Professor B. Bolin, who occupies one of the two chairs in meteorology found in Sweden, the other being held by Professor G. Liljequist of the University of Uppsala (see article "Meteorology in Uppsala," July *ESN* 31-7:266). The Institute has a yearly budget of some $125,000 which is used mainly to bring well-known scientists to Stockholm for a year. Professor T. Sasamori of National Center for Atmospheric Research (NCAR) Boulder, Colo., has been on the faculty since the beginning of the past academic year; according to him, Stockholm is a good place to be in the winter if one wants to work! The institute's financial support comes from a direct annual grant from the Swedish government through the University of Stockholm, and thus it enjoys a rather special status not held by other institutes or departments. Also, its relations with the Meteorology Department are very close since it shares the same physical space as the Department, and many of its members are on the meteorology faculty. Therefore, the Institute plays a unique role both on an international level through its visiting-scientist program and on a national and university

level in contributing to the scientific life of the Department.

Docent H. Sundquist is the Department's Chairman and the Associate Director of the Institute. The Department has about 30 faculty members and students, about a dozen of whom are studying for their Phd. Sundquist complained about the increased administrative load, and I cheered him up by saying that this malaise is shared by many departments in the UK and the US. On 1 July of this year the Swedish University System was decentralized; this shift in higher-education policy in Sweden, which might have a strong bearing on educational policies in other European countries, has been reported in detail by J.W. Miller (*ESN* 30-5:212) and the reader is strongly urged to glance at that article. The University system is being broken into six regions, each having its own university which will be responsible for catering to the regional needs. These needs, being of an applied nature, may steer the universties into rather applied research; there is also the danger that some of society's choices may tend to be shortsighted and could impair fundamental research currently found at various universities.

The Department's research can be roughly divided among three broad areas: (a) dynamic meteorology and geophysical fluid dynamics, (b) atmospheric chemistry, and (c) atmospheric physics. In the first area, research focuses on the use of simple numerical models as tools for understanding the parametrization of various physical processes that cannot be explicitly accounted for since their typical length scales are much smaller than the grid size used in these numerical models. The word parametrization has here a meaning different from the one encountered in mathematics; it describes the art by which some of the limitations inherent in the sometime large mesh size found in numerical models is circumvented. To parametrize is to incorporate in some clever ways the physics found on scales smaller than the mesh size. A good example is cloud parametrization: physical processes occurring in clouds have scales ranging from microns (for the microphysics of water droplets) to a few kilometers for the characteristic size of a cloud, while the model mesh size may be 300 km. Therefore all the physics occurring on scales smaller than some 300 km cannot be explicitly handled but must be parametrized, i.e., accounted for in terms of the larger-scale variables.

Sundquist and one of his students are interested in these problems. Their large-scale model consists of a spherical, five-layer model extending down to 25°N in which a pressure-like quantity is used for the vertical coordinate. Two schemes of convective adjustments have been compared, and a Departmental technical report on this work has been published. Sundquist is also interested in the parametrization of forced convection and condensation. These occur in a stable atmosphere when an air parcel is mechanically (rather than thermally) Lifted to a level at which its water vapor condenses. Atmospheric flows over mountains are other examples in which this forcing takes place; it is also found near frontal zones where these discontinuities can act as wedges and can lift air parcels. Sundquist is interested in predicting the amount of cloud water under these conditions and has been using a one-dimensional numerical model that seems to give a reasonable cloud-water content. The next step is to include this model in a three-dimensional prediction model. Much of this work will probably appear in the *Quarterly Journal of the Royal Meteorological Society* (of the UK) in the near future.

Studies on the initialization of numerical models are important, for a number of spurious processes can be excited and, if unchecked, can destroy the accuracy of the forecast. Artificial gravity waves that are created by the initialization procedure in these numerical models are under study. The work has both a theoretical as well as a numerical character. Sundquist deplored the limitations imposed on this type of research by their present computer capabilities (CDC 6400, whose memory is too small). Negotiations are underway to double its present memory capacity; much cooperation and interaction in work dealing with numerical modeling is envisaged by this Department with the European Centre for Medium-Range Weather Forecasts (see *ESN* 30-1:42).

Sasamori is interested in developing simplified atmospheric models in which some of the large-scale processes that could be accounted for numerically

are parametrized. For example, the heat flux due to large-scale transient as well as stationary atmospheric eddies and the heating due to sinking motions occurring in the atmosphere as a result of the general circulation are parametrized. Some of his results provide surprisingly good agreement with data and give hope for understanding these fundamental and complex processes in simpler terms. The interested reader is referred to a previous paper of Sasamori entitled "A Statistical Model for Stationary Atmospheric Cloudiness, Liquid Water Content, and Rate of Precipitation" [*Monthly Weather Review* 103 (12), 1037-1049 (1975)], to which this work is a sequel.

In the area of atmospheric chemistry, Bolin has been interested in the cycle of various chemical components like CO_2, sulfur, and nitrogen. He delivered The Symons Memorial Lecture of the UK Royal Meteorological Society in London under the title "Role of the Atmosphere in the Biogeochemical Cycle." He is developing one-dimensional numerical models in which the scouring of water droplets and their evaporation is modeled as a sink-source term for the aforementioned chemicals. The model is again of a statistical nature, i.e., even the large-scale atmospheric processes are parametrized.

Somewhat similar research is carried out by H. Rodher. He has been with the Department since 1965 except for the period 1972-1975, when he taught *Meteorology in Nairobi*. He is interested in developing numerical models in which the chemistry as well as the meteorology is present. He commented that, in the past, research in this area dealt either with diffusion-like models in which the chemistry is practically nonexistent or with chemical models in which dynamic meteorology is practically nonexistent.

In cooperation with Dr. I. Isaksen of the Institute of Geophysics, University of Oslo, Rodher has developed a two-dimensional, spherical model in which the scavenging by clouds and water droplets is modeled. The lower boundary condition is taken at some 200 m above ground, and a distribution of sources and sinks of chemicals is prescribed at that level. A small mesh of 200 m is used in the vertical up to heights of 4 km; from 4- to 20-km height, these meshes are 1 km in size. The horizontal grid is very coarse (10° latitude by 10° longitude). The scavenging function is also fixed in time and space and is obtained from climatological data.

At the upper boundary, the downward flux of certain gases as well as the solar radiation is prescribed as a function of location and time of the year. Extensive tests were made using water vapor as a tracer gas since it is widely measured. CO is also a good tracer gas for testing the model since it has a long lifetime and its concentrations exhibit marked variations with latitude; also its sources and sinks are well known.

The third research area deals with atmospheric physics, i.e., with the physical chemistry of processes taking place in upper atmospheric layers. This research involves the design of field experiments, acquisition of data, their reduction, analysis, and interpretation. Docent G. Witt, who has been with the Department since 1954, is in charge of a group of five graduate students, some of whom transferred to the Meteorology Department from the Departments of Physics and Chemistry.

Research is being done at altitudes in excess of 50 km by means of sounding rockets launched from the northern tip of Sweden (see *ESN* 30-6:287-289). It deals with studies of airglows, auroras, noctilucent clouds, minor constituents (NO_x, O_3, etc.) and involves several areas of research in classical physics (optics, spectroscopy, aeronomy, etc.). The Department designs many of the experiments and builds the scientific apparatus. Scientific collaboration with the Norwegians, French, Belgians, Germans, and Canadians as well as US scientists has taken place.

Stockholm remains an active and attractive center for researchers in a number of fields dealing with atmospheric dynamics, physics, and chemistry. (Albert Barcilon)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

THE INSTITUT DE MECANIQUE OF GRENOBLE

The Institut de Mécanique de Grenoble (IMG), directed by Dr. G. Lespinard, is a research center comprising full-time scientists from the Centre National de la Recherche Scientifique (CNRS) and some of the faculty members of the Université Médicale et Scientifique de Grenoble, the Ecole Nationale Supérieure d'Hydraulique and the Institut National Polytechnique de Grenoble. Each of these four research groups is autonomous, but all share the administrative burdens of the IMG group. The four groups differ in size, but all are fused by their common interests in the various facets of fluid flow. The groups' designations and their respective numbers of scientists are as follows: Hydrology (14), Soil Mechanics (41), Hydrodynamics (31), and Fluid Mechanics (21). I will discuss in some detail only the activities of the last two groups.

The Hydrodynamics Group, under the direction of Dr. J.P. Germain, is divided into four sections, each headed by a section leader. The problems considered by these sections fall under: (1) Waves and Tides, (2) Theoretical Water-Wave Studies, (3) Experimental Water-Wave Studies, and (4) Cavitation. The first section is headed by Dr. G. Chabert d'Hières who, some fifteen years ago, was responsible for the design of what is probably the largest turntable in the world (14-m diameter). The motivation for such a gargantuan piece of apparatus lies in the development of a scale model capable of accurately modeling tidal oscillations in the English Channel. At that time, France was envisioning construction of a huge tidal power generation station in the Bay of the "Mont Saint-Michel," off the coast of Brittany. The experimental set-up ingeniously modeled the energy input as well as its leakage, the mean currents, and the dissipation due to the shallowness of the Channel. Model predictions were found to be within 1% of observations. The coastal outline was then modified to account for the tidal power-generation station, and it was concluded that such a station would not appreciably affect the tidal regime in the Channel. Dr. C. Le Provost, who is in that group, has refined tidal theory in the last few years and discovered some new tidal components. He was involved in some of the experiments that measure the height of the free surface by means of a fine vertical needle that is made to oscillate at 50 Hz. These oscillations break the free surface and eliminate spurious errors due to surface-tension effects; a servomechanism adjusts the vertical position of the needle so that it resides half the time in air and half in water; hence, the mean position of the needle is indicative of the water elevation. Le Provost's research interests have shifted somewhat toward the development of numerical models that represent conditions either in the experiment or in nature. The models use conventional schemes for wave motions and also use new algorithms as well as finite-element and spectral methods.

Also involved in these studies are Professor J. Kravtchenko and Drs. R. Carcel, B. Bertrand, and H. Didelle. They are using this rotating platform under contract to perform several simulation studies pertaining to coastal circulation along the Brittany coast and atmospheric circulations in the Alsace plain. Such studies are being sponsored by Electricité de France, which has a major commitment toward establishment of nuclear power plants in these locations. Didelle is doing an experiment to determine the recirculation in the plain of Alsace caused by the presence of the Vosge mountain ridge. These mountains, only about 1000 m high, are embedded inside the planetary boundary layer which extends to about twice this height. One of the experimental difficulties, then, is to provide a thick enough boundary layer and to analyze the effect of the mountains on the boundary-layer flow. For air, under laminar conditions, the boundary-layer thickness is about 1 cm. Therefore, to provide for a thicker boundary-layer the flow must be rendered turbulent. This is achieved by a variety of grids arranged in such a fashion that they disrupt the flow moving over these obstacles and render it turbulent.

The second section, dealing with the theoretical treatment of water waves, is headed by Germain. He and his students have been interested in critically reconsidering the various theoretical representations of surface gravity waves. These waves are

characterized by a set of parameters and, depending upon the numerical magnitude of these parameters, different theoretical representations are used. Germain and his students have systematically explored the nondimensional space in which each point characterizes a given wave regime. He pointed out that, in order to obtain an analytical representation of surface gravity waves capable of handling the most general boundary conditions, one must include, in addition to the conventional terms, an infinite series of exponentionally decaying terms. For more details, the interested reader is referred to the article by Germain and L. Gulli, "Eau peu profonde: Passage d'une onde sur une barrière verticale immergée," *Numéro Spécial des Annales Hydrographiques* (1977) and to one by A. Temperville, "Interaction non-linéaire dans la théorie de l'eau peu profonde," loc. cit.

By using these techniques, Germain was able to verify with great precision some of T. Maxworthy's experimental findings on solitons reported recently in the *Journal of Fluid Mechanics* [76, Part 1, pp. 177-185 (1976)]. He hopes to submit his work to this journal in the near future. A solitary wave, first observed well over a century ago, is a localized travelling wave with a single crest and, strictly speaking, of an infinite wavelength. A soliton is a solitary wave solution of a wave equation that preserves its shape and velocity upon collision with another soliton. This concept has applications in theoretical science and engineering. The interested reader is referred to a review paper on the soliton concept: "The Soliton: A New Concept in Applied Science" by A.C. Scott, F.Y.F. Chu, and D.W. McLaughlin, *Proceedings IEEE* 61(10), pp. 1443-1483.

By introducing stretched coordinates in space and slightly modifying the time variable, Germain obtains a set of equations that describes the propagation of solitons. These equations can handle propagation in both directions, while some of the more standard equations in this field are limited to the description of soliton dynamics in a single, chosen direction. Germain argues that nonlinear interactions between solitons are not the same when the solitons move in the same direction as when they move in opposite directions. In the latter case, as they cross each other they interact for a short time, while in the former case the interaction takes place over a much longer time.

Mrs. Pinette, one of Germain's students, is considering the propagation of a solitary wave onto an obstacle of circular or other cross section. Mr. M. Helal, also one of Germain's students, is investigating the propagation of conoidal waves (waves whose shape is more complicated than the sinusoidal waveform) in a tank containing two fluids of slightly different densities and thicknesses. These conoidal waves are excited at the interface between the two fluids when the tank is made to oscillate about a horizontal axis in such a manner that one of the internal modes is excited.

Dr. C. Marcou is in charge of the third section dealing with experimental studies of water waves. He works in close cooperation with Germain's section since many of the theories are tested in the laboratory's wave tanks (one 25 m x 0.8 m x 0.75 m, another 35 m x 1.2 m x 0.5 m, and two 2-m-long wave tanks). Various more-or-less sophisticated wave generators are also used. One area under investigation deals with the propagation of waves in water at rest. If the wave maker has a sinusoidal displacement, the first few waves exhibit characteristics very different from those generated after a steady state is reached. The first few waves are good approximations to solitary waves. The generator is stopped when the first wave reaches the opposite end of the tank. When the depth—made nondimensional by dividing by the wavelength—falls below 0.12, several secondary waves appear.

Another study deals with the propagation of waves through an immersed slit. Part of the wave is reflected and part is transmitted, and two strong eddies form near the entrance and exit of the slit.

Dr. E. Hopfinger is in charge of the Fluid Dynamics Group. The main research areas deal with turbulence and transition in homogeneous as well as stratified flows and with magnetohydrodynamics (MHD); both analytical and experimental studies on turbulent flows are carried out. Hopfinger has collaborated with scientists of the Laboratoire d'Electrostatique (also at Grenoble) in investigating experimental problems of convection in the

presence of a destabilizing body force induced by electric fields [see Lacroix, Atten, and Hopfinger, "Electroconvection in a dielectric liquid layer subjected to unipolar injection," *J. Fluid Mech.* 69, 539-563 (1975)]. Hopfinger is also interested in the generation of turbulence across a density interface [see Hopfinger and Toly "Spatially decaying turbulence and its relation to mixing across density interfaces," *J. Fluid Mech.* 78, 155-175 (1976)]. He is seeking support from the CNRS to investigate the decay of three-dimensional turbulence and its evolution into two-dimensional turbulence when a grid is made to oscillate vertically in a rotating cylindrical container filled with a liquid.

Hopfinger is also involved with the dynamics of density currents. Such currents are induced by the presence of fluids of different densities slipping past one another. Meteorological applications involving density currents are numerous; yet, Hopfinger's research deals with a more spectacular natural phenomenon: avalanches or, more precisely, powder avalanches, for, as an avalanche forms, dry snow crystals are picked up at its leading edge, and the density of the fluid inside the avalanche is very different from that of the ice crystal's free air. An experimental study simulated this flow in the laboratory by using brine and fresh water layers, with the brine flowing on an inclined plane. The density ratio found in the natural phenomenon is not modeled properly; thus one must allow for such a shortcoming when interpreting laboratory or field data. For more details, the reader is referred to Tochon-Danguy and Hopfinger, "Simulation of the dynamics of powder avalanches," *Proceedings of the Grindelwald Symposium on Snow Mechanics*, No. 114, 1974.

The Institut de Mécanique de Grenoble is an exciting place to spend a sabbatical year for US investigators working in the areas discussed above. Research support for such activities in France is difficult to come by, but this group is trying hard to enjoy more interaction with the English-speaking scientific community. (Albert Barcilon)

ENERGY

WIND POWER—THE WEST WIND DOTH BLOW

To the visitor to Britain, it will come as no news that the British Isles are situated in one of the windiest regions on Earth. The strongest winds, averaging 7.8 m/sec, are to be found on the west coasts of Ireland, Wales, and Scotland. Other coastal winds clock in at 5.6 to 6.7 m/sec on the average; inland winds go at about 4.4 m/sec. A survey conducted by the Electrical Research Association in 1955 identified 39 sites where the average wind speed exceeds 8.9 m/sec, a figure then thought to mark the threshold for the economic generation of electrical power by wind-power harvesting devices.

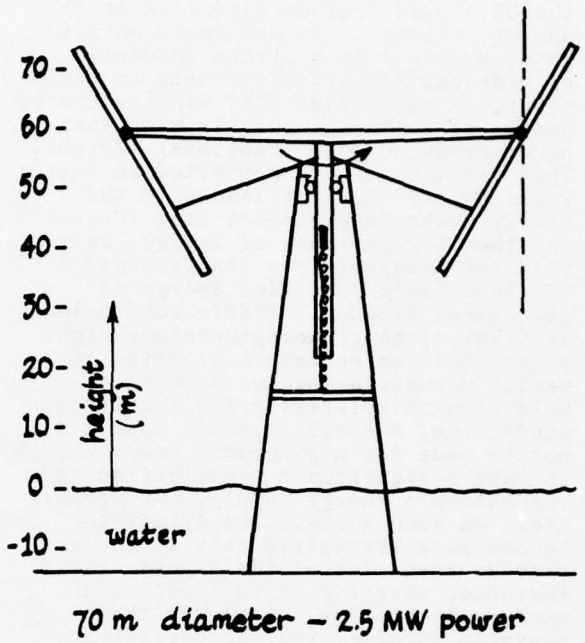
It is likely that a good number of additional land sites can be located, if the UK authorities choose to do so. What, then, is the status of wind-power development in the UK, and what is its potential for becoming an important power source for the country? This report looks first at some technicalities of windmills, then at the economics and siting problems for the UK. (The International Symposium on Wind Energy Systems held at Cambridge on 7-9 September 1976 has been reviewed by R.H. Nunn recently; *ESN* 30-11:494 and C-31-76. These reviews should be consulted for a broad global accounting of wind-energy technological developments.)

The first fact of life about windmills is that their theoretical maximum efficiency is usually taken to be 16/27 (59%). This limit follows from the fact that extraction of power from winds entails slowing the wind down on its passage through the area swept out by the mill blades. The second fact is that the energy theoretically available for windmills varies as the cube of the wind speed. This would seem to imply that the windier sites are preferable, and provision should be made to use the fiercest winds that develop. The first inference is generally true; the second is misleading. In fact, the economic optimum is reached when the rated wind speed for the windmill is

1.5 to 2 times the average speed. At higher speeds, the load-factor drops off from a typical figure of perhaps about 40% to 20%. Also, high-wind speeds pose a severe construction problem, since large stresses may be developed that have wrecked windmills in the past. The designer's goal is to provide some means for protecting a windmill from high gusts, ignoring the apparent loss in power-harvesting.

The UK's leading new windmill design, invented by Peter Musgrove, Reading University, pays particular attention to the wind-gust problem. While windmills have historically been horizontal-axis devices usually, the simplicities and economies of vertical-axis mills appear to be emerging, and Musgrove's mill, called a variable-geometry vertical-axis windmill (VGVAW), follows this trend. His design starts with the ideal aerodynamic configuration for vertical-axis mills—H-shaped, with blades that are straight and vertical, connected to a horizontal cross-arm; see the schematic diagram. If the connection is rigid, excessive bending stresses develop in the cross-arm at high speeds. In the VGVAW the blades are hinged to the cross-arm. Tie wires, used to feather the pitch, run from each blade to an extension spring housed within the central rotating shaft. This shaft is supported on bearings, and it transmits the mill's output power to the load at the base. The more direct connection of the rotating members to the load in vertical-axis mills is an advantage over horizontal ones.

In winds of average speed, the spring tension holds the blades upright against a hinge stop. When the speed increases, the increased centrifugal forces make the blades lean away from the vertical, reducing stresses. The spring constant is chosen so that the blades become almost horizontal in very strong winds; no additional devices are required. Furthermore, the straight-blade design permits inexpensive construction. In the 3-m-diameter mill in operation on the Reading University campus, the blades are made of mahogany. Fiberglass and extruded aluminum are being considered for larger models.



Schematic diagram of the variable-geometry vertical-axis windmill, mounted in shallow waters. The blades are depicted in a position canted from the vertical (dashed line) by a reasonably strong wind.

Musgrove's design has been patented by the National Research Development Corporation and is being licensed to manufacturers. A wind-tunnel testing program has been set up at Kingston Polytechnic to help optimize new mill designs.

A disadvantage of vertical-axis mills, compared with horizontal ones, is that they are not self-starting, since the torques exerted on opposite blades, starting from rest, counterbalance. This is not the case once the mill is set in revolution, when the torques depend on the velocities of blade elements relative to the wind velocity. An advantage of vertical-axis mills is that they do not require being oriented for wind direction, as is the case for horizontal ones.

There apparently is agreement in the UK that innovative windmill designs can and will be developed. Disagreement centers on the extent to which

the UK should include windmills in its energy strategy. As one would anticipate, Musgrove is a strong advocate of pressing forward vigorously on wind power, in the belief that wind-generated power can compare favorably with the power produced by conventional systems. This position is not supported in Energy Paper Number 21, just issued by the Energy Technology Support Unit (Harwell) for the UK Department of Energy, entitled *The Prospects for the Generation of Electricity from Wind Energy in the United Kingdom*. ETSU's conclusion is "that although aerogenerators might be economic on certain hill sites if series manufacturing costs could be held down at relatively low levels of production, a clear economic case cannot be made for a programme large enough to make a significant contribution to the nation's energy supply. Aerogenerators on such a scale are likely to become more attractive only in the more extreme scenarios of the future, for instance, scarcity of fuel oil or a nuclear moratorium. To cover these possible futures, the prospects for achieving better performance and cost comparison should be kept under review so that, should the prospects improve, the design and construction of demonstrations plants on operational sites could proceed with minimum delay."

Responding to arguments regarding aesthetics, Musgrove has concluded that banks of windmills should be sited in shallow offshore waters, as the Dutch intend to do. Presumably, aesthetic blight is thereby reduced, and the average wind speeds offshore may be favorable; a survey is in process. Furthermore, Britain has a large area of windy shallow waters near its shores, particularly in the southern part of the North Sea, where there is a large region with water depths less than 20 m. Siting in deeper waters would increase construction costs, and farther from shore the electrical-transmission costs would be excessive.

In shallow locations, Musgrove would construct banks consisting, typically, of 400 mills in a 100-km^2 area. Each mill would be rated at 2.5 MW (with a 40% load factor), making the bank a 1000-MW power source—a figure that is typical of large power plants now under construction. The packing of mills in this area is reasonable, since there is negligible velocity interference between them when they are located about 30 diameters apart. The anticipated cost—a very tricky quantity to forecast—is variously reported to be somewhere between £150 and £250 ($250-400) per kW. This does not include the cost of energy storage, a vital adjunct to wind-power systems.

On the question of storage, Musgrove has pointed out that the major natural gas fields are located in the southern North Sea and would make ideal energy-storage reservoirs when exhausted. The proposed technique is to store energy by compressing air into these reservoirs. A criticism of this suggestion is that the energy that would be stored in this manner is of the same order as the energy required to provide the air compression. Furthermore, the air would be heated in the process. Musgrove recognizes the heating problem but believes that it merely points to an initial period in which the temperature is raised to a steady-state value; critics say that that temperature exceeds a safe limit for the rocks that form the reservoir walls.

Storage provision is required by the intermittence of wind power. The same is true of wave power, an energy alternative that is receiving even more attention in the UK than wind power (and will be reviewed in a future *ESN* article). As one man stated to me, "The waves will come rolling in if there is a wind anywhere across the Atlantic, but a windmill needs wind blowing 'on the spot.'" The full argument concerning storage must be immersed in a total energy strategy, however. The inclusion of wave power as a significant but restricted contributor to a national power grid could minimize the disadvantage of intermittence that wind power must bear.

A comparison between wind power and wave power is one that energy authorities must make. Musgrove has already made such a comparison in a written contribution to *Nature* [262, 206 (1976)]. In it he concluded that wind-power systems are the more attractive. The argument here centers on the energy-recovery period—the amount of time that a system must operate to recover the energy required to produce and install the system. His estimate, admittedly crude, for windmills is about 1.1 years. In the case of wave-power systems (in particular, one being developed by S.H. Salter,

Univ. of Edinburgh), Musgrove calculated a recovery period of 16 years. This latter figure is fully contested by wave-power advocates, who would reduce the estimate by at least a factor of 100. Apparently the estimated recovery period for windmills is accepted as reasonable. The argument on the recovery period for wave power will be outlined in the future *ESN* article on wave power.

All that seems safe to say in conclusion is that, although final answers are uncertain, wind-power research and development is warranted in the UK. Musgrove's "fall-back" position coincides with the full evaluation of wind-power potential by critics. That is, even if the winds are not utilized for large-scale, general-purpose power applications, there is a substantial demand for small windmills with outputs in the range from 0.1 to 10 kW, primarily on farms and in remote locations. Newer windmills appear to be combining very attractive engineering design with very reasonable aesthetic design. (A. Sosin)

NIGHT-STORAGE HEATERS—ENERGY CONSERVATION, RESEARCH, AND ECONOMICS

Standing relatively inconspicuously, and certainly innocuously, in every other ONRL ground-floor office is a metal-cased contraption approximately 4 ft wide x 3 ft high x 1 ft deep. Since it apparently makes no sound and possesses no doors or drawers, its function is less than obvious. The major clue is two knobs. One is marked OUTPUT—HIGH, MEDIUM, LOW; the other is marked INPUT—MAX, with a notice: DO NOT COVER THIS HEATER. "Ah, we are getting warmer."

I shall not attempt to carry the mystery any further. The unit is a night-storage heater, with an additional outlet duct to an adjacent room. Yet I suspect that there are many in the US who might well ask at this point, "Just what is a night-storage heater?"

Night-storage heaters are (or were—see the end of this article) a significant factor in Britain's energy equation. The purpose of storage heaters is straightforward—electrical energy is delivered to the heater during the late night and early morning hours, stored as internal host energy, which is delivered during the rest of the day. They are attractive to the electrical-supply industry because the input energy can be delivered when the demand is relatively low—during the off-peak hours. They are attractive to users because the price during off-peak periods is reduced (if a suitable two-rate meter is installed), reflecting the lower cost of supply.

Storage radiators, as they are also called, were first introduced into the UK in the 1950s, intended for use in commercial and industrial premises. In 1957, the British Electrical Development Association published its recommendations for the design, installation, and use of this equipment. Because they were intended for commercial and industrial usage, their styling and size were hardly considered, the storage method was not optimized, and no thermal-charge controller was incorporated; only room thermostats, anticipatory controllers, or time-switches were used.

By 1961 some manufacturers offered domestic units, supported by a national advertising campaign. The growth over the next decade was tremendous. In 1962-1963, the storage-heater load was 600 MW; in 1973-1974, 13,585 MW. These figures were further reflected in the average daily electric utilities' load factor (i.e., ratio of power used to power available), which went from 72% in 1960-1961 to 86% in 1972-1973. From the consumer's vantage point, the success of storage heaters can be traced to two considerations. First, the night electricity tariff made electrical energy no more costly than alternative fuels. In 1976-1977 in London, the daytime rate (0700-2300) was 2.225 pence per kWh and the night rate, 0.932. Second, the storage systems required only a small capital outlay, and installation costs compared favorably with those of alternative fossil-fuel domestic central-heating systems. Thus, the storage systems were very attractive to the occupiers of existing houses that had no central heating (still not uncommon) and to public housing enterprises in areas not served by gas.

Three forms of storage radiators are available. The basic one operates without moving parts, controlled simply by an input-charge controller. The

level of input is manually set by the consumer and adjusted only once or twice per year. As the heater discharges, it continually warms the house throughout the 24 hours. A second class includes the fan-assisted and damper-controlled radiators. In both of these, the heat left in the core towards the end of the day can be extracted, with the use of either manually or automatically set controls. Finally, there are storage fan heaters, possessing the highest input ratings. They include more substantial core insulation and contain a fan to distribute warm air, controlled by a thermostat either integral with the heater or preferably remotely sited in the room. The amount of charge accepted is generally established by a thermostat located in or near to the core. Maintenance requirements are almost nil. A typical cost for a 3-unit storage system installed in a 3-bedroom semidetached house is about £350 ($600); with current available interest arrangements, this would be approximately £100 per year for a five-year period. A still more sophisticated development is the "Electricaire" system, a central-core ducted-air heating system that resembles conventional American heating systems in layout and is more appropriate for new houses.

The research challenges of storage heaters lie mainly in the thermal-transfer design considerations and in the selection of materials for optimal insulation and energy storage. A summary of the different output systems (supplied by the Electricity Council) lists the following types, along with their costs and flexibilities: case emission (very cheap; none); convective ducts with dampers (moderately cheap; limited); fan-assisted ducts (moderately expensive; moderate); fan-controlled ducts (moderately expensive; high); air-water heat exchangers (expensive; high); steam-water heat exchangers (very expensive; high). Developmental work on the last has been discontinued at the research-prototype stage.

Thermal insulations are given as the following, along with their costs and specific thermal resistivities: mineral-fiber blankets and boards (cheap; low); ceramic fiber (expensive; medium); ceramic/mineral powders (medium; combined storage and insulation); silica aerogels (expensive; high); evacuatable fibrous insulation (very expensive; switchable). The last insulation was not developed beyond the research stage.

Storage materials include the following, along with their costs and volumetric heat capacities: water (cheap; very low); fosterite bricks (moderately cheap; medium); ferric-oxide bricks (moderately cheap; high); alloy cast iron (expensive; high); molten $NaNO_2/NaNO_3$ (---; high); molten aluminum (---; high); calcium-carbonate dissociation (cheap; very low). The last two storage materials were not developed beyond the research stage.

The listing above should alert the reader to the overwhelming factor in the development of storage heaters—cost. In general, the items on each list become more sophisticated—and more costly toward the end of the list. But only a small amount of sophistication is tolerated by the economics here. For example, fan-control and ducts are about the full extent of sophistication for room radiators, and simple case emission is widely used. Only central heating systems may resort to air-water heat exchangers. Ceramic bricks dominate the usage among storage materials, although cast iron is common in central units. Water, obviously the least expensive from a material-investment point of view, actually involves a high capital cost and is restricted to custom-built systems, and refractory concrete is limited to prototype systems in which the storage is distributed over the walls of the rooms. The molten-salt system was abandoned because of inadequate heat transfer once a solid phase has started to form and because of corrosion.

The optimization and design of materials are the concern of the Materials Science Section at the Electricity Council Research Centre (Chester, Capenhurst, UK), under the direction of W.T. Eeles. In this work there is considerable room for improvement in materials, but the section has found technical sophistication secondary to initial cost and reliability. For example, they developed a ferric-oxide core material and an evacuatable insulation jacket, to reduce the size and to allow controllable output in a free-standing radiator. The core material found a market, but not as intended, in central storage units. The vacuum insulation did not get out of the laboratory because, even in mass-production, the fabrication costs of

the envelope would have been excessive and the reliability questionable.

It might seem that the US would do well to consider promoting storage heaters in its energy-conservation program. Certainly the record in Britain up to 1973 leads to this conclusion. Then a funny thing happened. In 1973, the market growth of storage heaters and technical advances virtually ceased.

Clearly 1973 is the year of OPEC. Why should the price of oil affect electrical storage heaters? The first step in the answer to this question is obvious. The price of oil impacted directly upon the price of electrical energy; the cost of electrical energy has more than doubled since 1973. Nevertheless, the differential between day and night rates has generally been preserved. But—and this is the key—the night electrical rate is now usually higher than the cost of gas-fired systems. To compound the difficulties, the flexibility of gas is greater. Storage heaters require an essentially 24-hour heating program; gas systems are characterized by almost instantaneous response. Furthermore, those clever people down at the Gas Board have been busy with their own engineering effort. Britons can now purchase a wall-hung gas "boiler," approximately 2.5 ft high x 2 ft wide x 1 ft deep, that vents directly to the outside (requiring no chimney) and consumes no precious floor space.

The history of night-storage heaters in Britain, it seems, demonstrates the uncertainties that energy-policy planners face and the direct influence of market considerations upon laboratory research on low-technology applications. It will be interesting to observe how often, albeit in different forms, this example is repeated in the developing energy program in the US. (A. Sosin)

ONRL REPORTS

See the back of this issue for abstracts of current reports.

A PLACE IN THE SUN: SOME SOLAR ENGINEERING IN ISRAEL

The search for energy alternatives in Israel, a land of seemingly continual sunlight, focuses on solar energy very quickly. The optimal method of harvesting this energy is a matter of research in a number of Israeli institutions. Professor A. Braunstein, Holon Campus, Tel-Aviv University, has adopted the definite position that solar energy will be the prime energy source for Israel—indeed for a major fraction of the world's nations—in the not too distant future and that solar cells are the preferred means for collecting this energy. Given this starting point, Braunstein has decided to take the next step—to engineer the solar-cell systems that will be needed.

Braunstein and his group, consisting of three senior people, five MS- or PhD-candidate students, and little financial support, have, accordingly, been occupied with the following activities: operation of a solar-powered automobile, design of a radiation (insolation) meter, design of a solar house, research on a new battery-storage system, and general solar-system engineering.

Solar-system engineering starts with the acceptance of solar cells and their characteristics, namely, low dc voltage and low current generation per cell. The obvious fundamental problem, considered by Braunstein *et al.*, in an elementary initial analysis, is the optimal method of series and parallel connections. The problem becomes more realistic, more difficult, and less determined when ideality is removed and "fault conditions" are considered. Solar cells are not identical. One or more cells may become disconnected, leading to an open circuit in one or more parallel branches. Similarly, cells may become short-circuited. All of these are obvious faults that the systems engineer must consider.

Slightly less obvious is the problem posed by the shadowing of one or more cells from the sun. Braunstein *et al.* have provided a beginning basis for fault considerations in a paper in the *Journal of the Association of Engineers and Architects in Israel* (p. 48, Jan. 1976).

Still other system factors that have been examined include tilt angle

for the solar-cell arrays, tracking, and atmospheric contamination. Braunstein *et al.* have given the angles for maximum power output for various latitudes, and solar-declination values. Sun tracking generally is energetically advantageous, but the complications and expense make it questionable in application; in fact, Braunstein feels that tracking is not economic even in large systems.

The study of the effects of dust, sand, and other contaminants does not lend itself to mathematical calculations, and so Braunstein set up an experiment near Beit Dagan, Israel, in which the solar arrays, covered with Perspex (lucite) and Lectane, were maintained at a 30° slant.

The degradation of performance by contamination was quasiperiodic. From spring through autumn, the arrays were covered more and more with dust and other contaminants. By September, the efficiency had degraded to about 63-64% of maximum. With the advent of winter rains, the cell arrays were washed sufficiently to recover to the 90-95% level.

Solar systems are, almost inevitably, linked with energy-storage systems. Braunstein *et al.* have devoted their attention to battery-storage systems. They have examined performance characteristics during a variety of operating cycles. Since batteries form a major component of the cost of a solar-electric system, protection of batteries from excessive overcharge is important, and Braunstein *et al.* have designed a charging control system based on the use of E-cells. An E-cell is an electrochemical device with two electrodes, one coated with silver and the other with gold. The small current flowing through the E-cell causes a silver deposit from the silver-coated electrode onto the gold-coated one. As the E-cell is discharged, its voltage rises to about 0.75 V, a value determined by the silver-electrode substrate material. By use of a voltage comparator, the voltage of the E-cell can be employed to trigger a switching system and terminate battery charging.

Using E-cells as a basis, Braunstein has also designed an insolation meter that measures insolation levels continually; this radiation meter is currently available from a US producer. His concern with batteries as adjuncts to a solar-collector system has led him to the search for new battery systems; his group is currently examining a proprietary room-temperature system that Braunstein feels shows strong promise.

Braunstein's major system project of the future is the building of a one-family house, with the primary power derived entirely from solar power. All of the electric power is to be derived from solar cells; solar-panel collectors will be used for heating and airconditioning. Lead-acid batteries will provide the off-solar power. Construction is scheduled to take place in Tel-Aviv and Beersheva during a four-year period and costs will be approximately IL 4M (about $400,000).

The most sensational project that Braunstein has engaged in is the solar automobile. To prove that such a concept is not pure whimsy, he actually drives the automobile routinely. In fact, it should probably be more accurately termed a solar-assisted vehicle. It is a US-built "Citicar," powered mainly by lead-acid batteries. Braunstein has added panels of silicon solar cells to the roof and to the fronthood section. With 16 modules of 36 cells each, the solar supply contributes about 1 kW, according to Braunstein, for more than a 25% extra car range (normally ∿60 km). Despite the obvious current limitations in performance, he is enthusiastic about the eventual marketability of electric automobiles employing solar assistance for suburban travel and is looking into improving the driving features of the automobile (e.g., improvement in the relay system to provide a smoother drive). (A. Sosin)

ENGINEERING

ELECTRIC VEHICLE DEVELOPMENT CONFERENCE

On 31 May and 1 June 1977, a conference on electric vehicles (EVs) was sponsored in London by the Electric Vehicle Development Group, an organization devoted to advancing the design and utilization of EVs. While the group's membership is drawn from EV and battery manufacturers in England, the Continent was well represented among the speakers and audience at the

Conference. The presentations constituted a mixture of new developments, surveys of past work, and prognostications regarding the future of EVs. Unfortunately, as will be evident later, the sales motive adversely affected the credibility of technical data presented.

The opening address was given by Dr. E. McEwan (Joseph Lucas, Ltd., Birmingham), who made estimates of the future pattern of energy usage and the role of the EV. His forecast for nonnuclear fuels is unfavorable. North Sea oil, in his opinion, will not be a "bonanza" for England, for he considered it unrealistic to think that one country would be permitted to enjoy ample supplies of oil while neighboring industrial nations suffer shortages. Coal is available but not easy to obtain nor to use in an environmentally acceptable manner. He said that the "natural-food types" are promoting alternative sources such as solar and wave energy, but he expects their future contribution to be small—no more than 10% of the total demand. A wave-energy absorber 600 miles long would be required to furnish one-third of England's energy requirement, for example.

McEwan's conclusion was that only nuclear plants can supply Europe's requirements in the 2000-2025 period. Electricity will then be the major energy vector between source and consumer. Petroleum-based liquid fuels will still be used, he believes, in specialized applications such as aircraft propulsion, but such consumption will be minimized.

In McEwan's opinion, the electric automobile is still years away, but EVs for short, scheduled trips—such as buses and vans—have immediate application. He stated, however, that the time required to introduce a new form of transportation is about 25 years, and so effort on the electric automobile should begin now. His response to the objection that terrorists may obtain plutonium produced by breeder reactors was as follows: "The Eastern Bloc nations are going to build breeder reactors whether or not the West does so. Thus the Pu will be available anyway, and we can only hurt ourselves by not going to the breeder reactor."

Limitations of Electric Vehicles. Almost every speaker at the Conference mentioned the EV's limitations in regard to range and recharging time. G. Ratcliff (Electricity Council Research Centre. Capenhurst), pointed out that one gallon of gasoline contains as much energy as 850 lb of lead-acid storage batteries. The EV's energy requirement per ton-mile will be approximately the same as that of a gasoline-powered vehicle. Allowing for the difference in efficiencies of electric and gasoline motors, Ratcliff then concluded that the maximum range of EVs with Pb-acid batteries is equivalent to, at most, a few gallons of gasoline—perhaps 50 to 75 miles. Batteries of higher energy density will increase this range, of course; in the opinion of some speakers a five-fold improvement may be possible.

R.G. Acton (Oldham and Son, Ltd., Denton, Greater Manchester) explained the practical considerations that limit energy density in batteries. Inert components comprise over half of the total cell weight, and only a modest reduction in the weight of these components appears feasible. Acton expects the energy density of the Pb-acid battery to be increased about 20% in the next five years. Its present energy density was widely quoted in the Conference as 35 Wh/kg and was used in discussions of vehicle range. But, as was pointed out by C.D. Keizer (Technical University of Delft), 25 Wh/kg is a more realistic life-average value, and this number may decrease further under practical conditions of use.

Another basic limitation of the EV lies in the power capability of the charging circuit. Ratcliff stated that a gasoline pump that delivers 10 gal/min is supplying energy at the rate of 20 MW. An electrical conductor to furnish such power at domestic volatages would require a diameter of 16 in.; so such charging rates are out of the question. Acton pointed out that, for long life, present batteries must be charged over a period of hours. He expressed hope that a one-hour charge will eventually be possible without detrimental effects. This would in turn make the power capability of the charging point the limiting factor. He estimated that 50 kW might be required, and that this is the maximum one could hope to draw from a residential supply (50 kW/240V ≙ 200 A). Less ambitious numbers were cited by H.G. Plust (Deutsche Automobilegesellschaft mbH, Esslingen, FRG), who used 81 Wh/ton-km for the energy requirement of an EV and showed that a 120-V, 10-A

circuit in ten hours can provide enough energy for 148 ton-km, or enough to propel a 1.5-ton vehicle about 100 km (62 mi). Thus this modest charging-point power capability is sufficient to apply full charge to a typical vehicle.

There is considerable difference in the energy requirements of EVs as stated by different authors. While Plust used 81 Wh/ton-km, Ratcliff and Keizer used 98. The latter speaker gave an interesting breakdown of energy consumption in which he attributed 35 Wh/ton-km to rolling resistance (chiefly in the tires) and the remainder to kinetic energy that is acquired during acceleration but is wasted in braking. Obviously the energy requirement depends strongly on the type of driving. Data presented by O. von Krusenstierna (AGA Innovation Center, Täby, Sweden) at the 10th Power Sources Symposium, Brighton, England, are as follows: light suburban driving: 100-120 Wh/ton-km (1/25), normal town driving: 150-200 (1/16), severe stop-and-go driving: 250-300 (1/10). (The numbers in parentheses denote the effective resistance to motion expressed as a fraction of vehicle weight, based upon the mean of the energy values.) It appears that the energy requirements used by speakers at the recent Conference pertained to very favorable driving conditions.

It is clear that losses from acceleration followed by braking can be reduced by "regenerative braking." Here the drive motor is used as a generator to retard the vehicle and simultaneously to charge the batteries. With ideal regeneration, there would be no braking losses, and the effective resistance to motion would be the rolling resistance alone.

The feasibility of electric automobiles in urban areas was illustrated by D. Bayliss (Greater London Council) with statistics that 50% of automobile trips in the London area are shorter than 5 km, and 75% are shorter than 10 km. As a matter of interest, in 1910 there were 10,000 EVs in London, 6,000 of which were automobiles. Bayliss did state, however, that taxi and bus requirements in London—240 km/day and 180 km/day, respectively—are beyond the capability of present EVs.

While the utility of EVs for short trips was widely accepted at the Conference, the feasibility of battery exchange as a means of achieving longer ranges was a matter of some dispute. The functioning of battery-exchange stations was discussed by M. Bradford (Electrical Research Association, Ltd., Leatherhead, Surrey). In a typical large station he would expect about 1,700 exchanges per day with Pb-acid batteries and 600 per day with advanced cells such as Na-S. The gasoline-equivalents per exchange in the two cases were estimated to be 1.7 gal and 4.5 gal, respectively. Since each exchange unit might weigh 1,000 lb and cost £500 ($850), the weight and value of inventory for one day's operation would be substantial. In discussion it was pointed out that several batteries would be required for a day's journey by EV, and that the cost of these spares would have to be borne in some way by the EV owner. This led one participant to label the idea of battery exchange "foolish."

Trials of EVs. Several papers described in-service testing of battery-powered buses. H.G. Müller (Gesellschaft für Electrischen Strassenverkehr, Düsseldorf, FRG) discussed his company's work with hybrid vehicles. Two types are under test—an electric bus that operates either on batteries or on overhead lines, and one that carries both batteries and an internal-combustion engine. Regenerative braking is included in both vehicles. Performance figures are not available as yet.

A. Monroe (Greater Manchester Passenger Transport Service, Manchester, UK) discussed trials of two battery-powered buses. Both vehicles were designed and built in a collaborative effort with Chloride Silent Power, Ltd., and Joseph Lucas, Ltd. The larger bus has a capacity of 50 passengers, a top speed of 40 mph, and a range of 30 miles. To prove that EVs need not be sluggish, the smaller bus has been designed for lively performance; its top speed exceeds 100 mph. Both vehicles have regenerative braking. During a total of 14,000 miles of service, the availabilities of the vehicles have averaged about 40%, compared with the figure 80% for typical diesel-powered buses. The principal sources of trouble have been the regenerative braking systems and the speed controllers.

Work at Joseph Lucas, Ltd., in battery-powered vans was described by G.G. Harding, Director of Planning. The Lucas vans, one of which was used for demonstration rides at the

Conference, are powered by Pb-acid batteries. Their range is said to be 75 miles at 30 mph and 30 miles at top speed (numbers that seem rather high). Lucas has experimented with a vehicle powered by Zn-air cells but has abandoned the effort; they see no alternative to Pb-acid batteries for 5-7 years. (This statement forms an interesting contrast with the apparently favorable results obtained by Westinghouse and AGA in road trials of Ni-Fe and Ni-Zn cells. See ONR London Conference Report C-30-76, "Tenth International Power Sources Symposium," and *ESN* 30-11:497. Also see *ESN* 30-11:506.)

R. Haynes (consultant to Ford Motor Co., Brentwood, Essex) described the "Precinct 2," a two-passenger automobile built by Ford and powered by Pb-acid golfcart batteries. Public reaction to the car at shows and in road trials has been very favorable. Haynes estimates that 25,000 could be sold each year at a price of £4,000 ($7,000). He stated that the range is 100 miles at 40 mph, and that the batteries constitute one-quarter of the total weight.

In my opinion, the performance data given by Haynes are not consistent with Plust's (very low) value of 81 Wh/ton-km; if this value is used for the energy consumption E, one finds the range R in terms of battery weight B, total weight T, and energy density ε from

$$ETR = B\varepsilon$$

as

$$R\ [\text{miles}] = (B\varepsilon/T)\ [\text{Wh/kg}] \cdot (1/81)\ [\text{ton-km/Wh}] \cdot 907\ [\text{kg/ton}] \cdot 0.621\ [\text{mi/km}] = 7.0\ B\varepsilon/T.$$

Even for a new Pb-acid battery, where ε may be 35 Wh/kg, R is found to be only 61 miles for B/T = 1/4. For B/T = 1/3 (a more common value for EVs) R becomes 82 miles. If a life-average value for ε of 25 Wh/kg is substituted, and B/T = 1/3, a range of 58 miles is obtained. Any claim in excess of this for a vehicle powered by Pb-acid batteries should be questioned, and perhaps all performance data reported at the Conference should be viewed with some skepticism.

Progress in Design. P. Campbell (Univ. of Cambridge, UK) described his novel "pancake" electric motor, a device that can be incorporated directly into the wheels of EVs, eliminating the expense and losses associated with gearing. The motor uses permanent field magnets and an armature that consists only of a disk-like copper coil. Current reversal in the armature is accomplished, not by the conventional brush-commutator arrangement but by a solid-state switching circuit. Campbell exhibited a bicycle in which the 12-in.-dia. motor forms part of the front wheel.

Ratcliff stated early in the Conference that electric motors should run at high speed for maximum efficiency. He concluded from this that EVs should have transmissions, a position that is contrary to popular belief. Later in the meeting, W.A. Koumans (Technical University of Eindhoven, the Netherlands) and F. Dierkens (International Union of Producers and Distributers of Electrical Energy, Brussels, Belgium) described mechanical, low-loss transmissions with continuously variable speed ratios. These units are ideal for maintaining a constant motor speed, and they are especially appropriate for regenerative braking, as the generator speed can be adjusted to vary the braking effect. The speed ratio can at present be varied from 1:1 to 5:1.

Looking Ahead. In their presentations, Bayliss and Haynes attempted to describe the nature of land transportation in that future time when petroleum-based fuels are scarce and costly. Bayliss foresees a pattern of high-speed corridors served by scheduled transport such as trains and aircraft. Crossing these corridors will be secondary routes on which short-range and low-efficiency vehicles operate. This intercorridor service could be best provided, he believes, by battery-powered EVs.

Haynes sees a unique opportunity for EV designers. He estimates that the automobile of the future will have a capacity of four passengers, a cruising speed of 50 mph, and a range of 100 miles—parameters easily provided by advanced batteries. In his opinion, trips by auto in excess of 100 miles will be very uncommon; rail or aircraft will be used instead. Expanding upon Bayliss' concept of intercorridor service provided by EVs, Haynes pointed out the important role that rental vehicles will have in such a system.

While there may be a shortage of energy, there is no shortage of optimism among the EVs' supporters. Haynes believes that the trend toward reduced automobile use for long trips, and increased concentration of long-haul freight and passenger transport in non-highway modes, has already begun (especially in Europe), and that this would occur even if petroleum were plentiful. Proceedings of the Conference can be obtained from Peter Peregrinus, Ltd., P.O. Box 8, Southgate House, Stevenage SG1 1HQ (£7.50). (W.G. Soper)

RADIO INTERFERENCE IN MONTREUX

In Montreux, Switzerland, the Second Symposium on Electromagnetic Compatibility was held 28-30 June 1977 under the auspices of the Swiss Post, Telephone, and Telegraph (PTT) with the cosponsorship of the International Special Committee on Radio Interference (CISPR), Convention of the National Societies of Electrical Engineers of Western Europe (EUREL), Association of Polish Electrical Engineers (SEP), and other professional groups. Approximately 375 scientists and engineers from over 20 countries attended the 21 technical sessions and 4 workshops.

A highlight of the meeting was the opening address, "EMC and Telecommunications," by Mr. R.C. Kirby [Director of the International Radio Consultative Committee (CCIR) of the International Telecommunication Union (ITU), Geneva]. He noted the growth in scope and importance of EMC from the 1960s, when it was primarily a necessary military speciality, to the present, when it consists of: (1) Spectrum management to minimize interference between different transmitters; (2) Study and suppression of unwanted emissions and responses of electronic communication equipment; (3) Study, measurement, and modeling of the electromagnetic interactions among closely spaced systems (e.g., as on ships, airplanes, buildings, etc.); and (4) Study of the effects of nonionizing electromagnetic energy upon biological and physical systems and entities.

Kirby noted several opportunities for scientific study: (a) The application of classical statistical communication theory to optimizing total information flow where more than one system is operating, (b) Modeling the noise and interference environment, (c) Measuring signals and noise in the same terms as are used in models employed to calculate spectrum-sharing possibilities, and (d) Studying the biological effects of electromagnetic radiation.

Technical sessions on noise and interference focused upon high-voltage power lines and motor vehicles, computers, the statistics of noise, and the effects of noise on system performance. The sessions included the classical topics of shielding, immunity, specifications, and measurements (CISPR-type and automatic). The nuclear electromagnetic pulse (NEMP), control of transient response, and electromagnetic (EM) field (especially the near-field) measurement accuracy were discussed. Sessions on safety margins for flammable gas mixtures and the effects of fields on plants, birds, and mammals illustrated the need to consider side effects when using EM energy. The session on frequency management was timely because the forthcoming 1979 World Administrative Radio Conference (WARC) of the ITU is scheduled to review and revise as required the international radio rules and regulations, including the frequency-allocation table.

The 1500-Swiss-franc (SFr) first prize was shared by A.D. Spaulding (Institute for Telecommunication Sciences, Boulder, Colorado) for his paper "Optimum Reception in the Presence of Impulsive Noise" and A.P. Kalmakov (Leningrad Radio Research Institute), the author of "Analysis of Statistical Characteristics of Click Voltages Measured with a CISPR RFI (radio-frequency interference) Measuring Set." Spaulding used the model of the noise environment described in the paper "Statistical-Physical Models of Electromagnetic Interference," by D. Middleton (New York, N.Y.) to obtain optimum signal-processing algorithms for selected binary communication schemes (e.g., antipodal, orthogonal, and on-off keyed). These algorithms resulted in large (20-to-30-dB) potential reductions in the required signal-to-noise ratio for systems operating

in the presence of narrowband noise (from sources whose emission bandwidths are comparable with or narrower than the receiver's passband). The performance of locally optimum receivers was also treated.

Kalmakov described, theoretically, the probability distribution of click voltages to be expected from measurements made with an RFI measuring set of specified characteristics. The practically important case of Poisson-distributed pulses in pulse packets (which are caused by switching transients) was used as an example, and excellent agreement was obtained between the theory and the measured results.

The 1000-Swiss-franc second prize went to R.J. Hasler (Radio Interference Lab, Home Office, Stanmore, Middlesex, UK) and to Dr. R.G. Struzak (Institute of Telecommunications, Wrocław, Poland). Hasler's paper, "Measurement of External Immunity of Domestic Television Receivers—Some Problems and Their Solution," discussed a new type of remote sensor consisting of a photo-transistor package coupled through a fiber-optic link to a remote receiving unit designed to provide an objective measure of interference to TV video displays. Hasler also described a test-site design and procedures to generate an electromagnetic field that is uniform over a broad band of frequencies and over the required space.

In his paper "CISPR Quasi-Peak Measuring Channel with Extended Dynamic Range," Struzak used the technique of splitting the incoming signal into several amplitude subchannels to increase the sensitivity, linearity, and dynamic range of a CISPR meter without employing automatic gain control or other feedback techniques.

Two contributions received certificates for excellence. "Effects of Impulsive Disturbances on Car Electric Circuitry," by P.G. Galliano (I.E.N.G.F., Torino, Italy), who measured disturbances that can (under certain circumstances) irreparably damage the electronic ignition system of the car. The second was "A Simple RF Immunity Test Setup," by P. Groenveld (Philips Research Labs, Eindhoven, Netherlands) and A. de Jong (Dr. Neher Lab., PTT, Leidschendam, Netherlands), who described a parallel-plate transmission line that was built to test the susceptibility of audio-frequency equipment to electromagnetic fields in the band 20-200 MHz.

Many other fine papers were presented, including that by W. Hartman (Institute for Telecommunication Sciences, Boulder, Colorado) on "Objective Performance Measures for Voice Systems," which described a major advance in using linear-predictive-coding (LPC) techniques for deriving objective voice-intelligibility measures without having to resort to expensive listener panels or to not inexpensive analog processing techniques.

The Symposium was accompanied by an exhibition displaying material from 19 companies. Although it was impossible to attend all the sessions (three in parallel with workshops), it is fortunate that T. Dvorak (Swiss Federal University of Technology, Zurich) edited an excellent 576-page proceedings, "Electromagnetic Compatability 1977," which is available for SFr 95 from: EMC Symposium 1977, Box 97, CH-1820 Montreux, Switzerland, or from IEEE, 345 East 47th Street, New York, N.Y., as No. 77CH 1224-5EMC. The first Montreux EMC Symposium took place in 1975, and the third is planned for 1979. (George H. Hagn, Telecommunications Sciences Center, SRI International, Arlington, Va.)

A ONE-DAY MEETING ON ADAPTIVE PROCESSING IN UNDERWATER ACOUSTICS

Signal processing, particularly as it applies to underwater acoustic systems, has been a forte of the Loughborough University of Technology's Department of Electronic and Electrical Engineering since the arrival of Professor J.W.R. Griffiths from the University of Birmingham in 1967. Griffiths and his team have long had an interest in adaptive processing techniques, and it was to be expected that any meeting on this subject in the UK would be organized at Loughborough.

The one-day conference organized on 14 June 1977 by Dr. A.R. Pratt of Loughborough, for the Underwater Acoustics Group of the (British) Institute of Acoustics (IOA) had a two-fold

purpose. It aimed first at presenting the basic concepts of adaptive processing as applicable to the underwater acoustic case (in two introductory papers), and it then turned to the presentation of some recent research results. Two of the seven papers were given by US participants. The first of these, an excellent introductory talk, was by Professor P.M. Schultheiss of Yale University and the second by Dr. N.L. Owsley of the US Navy Underwater Systems Center, New London, who is currently on a year's exchange at the Norwegian Defense Research Establishment, Horten. All other contributions were from the United Kingdom except for one given by Dr. S. Prasad of the Indian Institute of Technology, New Delhi, who has been at Loughborough for the last year, which dealt with radio-frequency applications rather than underwater acoustics.

Sixty attended the meeting; all were from the UK except those noted above and a single representative from Holland and two from France. Of the total, about a dozen were from the unversities, almost exclusively from EE departments; about twenty were from industry, and as many from government defense research organizations. Only three were from elsewhere in government and these from the fisheries laboratories.

Schultheiss in his introduction took the position of the devil's advocate in regard to the application of adaptive techniques. He emphasized that an adaptive system cannot outperform a system designed with full knowledge of signal and noise and that, beyond this, resort to adaptive techniques immediately leads to complexity of instrumentation which rapidly becomes prohibitive. He proceeded to review various signal and noise situations, identifying and analyzing cases where adaptive techniques could be of potential value. Three possibilities were identified. First, that of one or more concentrated interfering noise sources; second, situations with short arrays (relative to the wavelength); and third, situations where the noise spectrum changes rapidly. In general, situations suitable for application of adaptive techniques were considered substantially more limited in the latter two cases than in the first. He concluded by again emphasizing that adaptation is no solution for failure to understand the signal and noise fields as fully as possible from the beginning.

Griffiths followed with a second tutorial lecture on adaptive array processing. He again noted that, with knowledge of the statistics of the wanted and unwanted signals being received by a system, one could design it in some optimal way. However, because of the unknowns that are almost invariably involved, one usually resorts in the end to conventional beam forming and a solution that is far from optimal. Attempting to learn about the signal and noise statistics with time and adapting to this information therefore offers interesting possibilities. He proceeded to give an impressive on-line computer demonstration of a simulated eleven-beam sonar system adapting through a series of iterations against a strong unwanted noise that was located successively in various directions relative to the desired signal or direction of look, as in Schultheiss' first case.

Dr. J.E. Hudson (Loughborough) described in his research paper an adaptive array with beamwidth control and in which the weight vector, which normally gets very large when the unwanted signal gets near the wanted one, is constrained to lie within a feasible region. He proceeded to discuss the effect of errors in sensor and channel gains and in wanted-signal direction on the performance of the system.

Dr. I. Roebuck (Admiralty Underwater Weapons Establishment, Portland, UK) continued with a discussion and comparison of adaptive and split-beam multiplicative processing, particularly when applied to weak signals in the presence of strong correlated interference. Noting some of the advantages of each, he proceeded to suggest a combination of the two as a possible means of achieving good performance with a system that might be simpler to implement than a more fully adaptive one.

Dr. T.S. Durrani and N.M. Murukuktla (University of Strathclyde and previously at the University of Southampton) discussed a set of algorithms suitable for determining the signal's bearing in the presence of noise from a circular array of small dimension compared with the signal wavelength (Schultheiss' second case). They then proposed an adaptive MMSE processor for the array which allows beam forming in several directions simultaneously and adapts sequentially until the beam-formed

outputs are consistent with the received sensor data.

Prasad discussed some work for radio transmission applications aimed at overcoming uncertainties in signal detection and multipath problems. His analysis was restricted to situations where the outputs of individual elements in an array may not all be directly available for individual processing, and where adaptive techniques would clearly not be optimal. He dealt particularly with alternatives where two beam-forming networks are available, one of which can be made adaptive. He proceeded to discuss a particular array of some eight elements; with simulated data he determined the effects of errors in the element positions, and he evaluated the system's sensitivity to variation in signal direction.

Owsley, after some general comment on the use of conventional beamformers to construct a more general adaptive-array beamformer and on the benefit of using additive processes rather than multiplicative ones, presented a paper entitled "Extent Invariant Signal Extraction" which offered an alternative to the classical Baysian approach to the problem of detecting signal presence.

Adaptive processing has been an area of intense study for many years and offers a number of possibilities to the underwater acoustics engineer. By highlighting in the introductory talks and again in the individual research contributions particular areas where adaptive techniques offer some possibility of superior system performance, the meeting served a most useful purpose. Interest in the possibilities of the techniques was reflected in the relatively good attendance for such a specialized meeting, especially as the meeting was not advertised well outside of the IOA's Underwater Acoustics Group. Application interest was evident in the balance in the attendance noted earlier.

The complete papers are expected to be available in the near future from Dr. B.V. Smith, Secretary of the IOA's Underwater Acoustics Group, Department of Electronic and Electrical Engineering, University of Birmingham B15 2TT, England. (Aubrey Pryce)

GENERAL

GOODBYE, GUTENBERG!

Apart from love, three things make the world go round: energy, materials, and information. We are up against a critical shortage of the first commodity, impending insufficiencies of the second, and an absolute glut of the third. Just in the field of chemistry, for example, *Chemical Abstracts* has 6 million abstracts covering the period 1900-1975. New papers are currently appearing at the rate of 0.4 million per annum, giving a further 10 million—a total of 16 million—references by the year 2000.

How to deal with this enormous outpouring of scientific and technical information—how to evaluate its quality, determine where it's needed, get it there rapidly, store it for future easy access, and do all of these cheaply—are challenging problems for librarians and "information specialists," as they also are for the scientific community itself, the ultimate producer and user of the information. To address these problems the Technical Information Panel of AGARD (H.E. Pryor, NASA, Chairman) held a two-day Specialists' Meeting at Lysebu, a fairly isolated conference center in the Oslo suburbs, on 22-23 June—the latter being "Midsummer's Day," when the sun in this area dips below the horizon at 10 PM (and gets right back up again at 2 AM, or so it seems).

The conference dealt with a broad range of future developments in communications, information technology and national policies and their impact on the work of information specialists. But the papers of most interest to me were those dealing with the ultimate fate of science journals—the question of whether or not Gutenberg's 500-year-old art of printer's-ink-on-paper will give way to "electronic journals" for handling scientific and technical information. There was a vague general acceptance of the idea that the demise of the conventional scientific journal is only a matter of time, but there was rather strong disagreement as to how soon this would come about and what one should do in the interim.

Dr. Helmut Grünewald, Director of Publications of the Gesellschaft Deutscher Chemiker (Weinheim, FRG), was not yet ready to abandon the world of printed paper. He explained that the conventional primary research journal tries to fulfill two functions—a current-awareness role and an archival role—and he asserted that it does both jobs rather badly. Secondary journals (like *Chemical Abstracts*) share in the dissemination function and provide a means of information retrieval. As a better mechanism for performing all these functions within the framework of print-on-paper, Grünewald advocated the system of a synopsis journal coupled with reproduction of the full text in "microform" (microfiche or miniprint).

This is the scheme of the new *Journal of Chemical Research*, which is sponsored jointly by the Chemical Society, the Gesellschaft Deutscher Chemiker, and the Société Chimique de France. It is published in two parts—Part S, consisting of one- or two-page synopsis papers, complete with display materials (such as graphs, etc.) where needed; and Part M, the full text of the original typescripts prepared by the author and reproduced in microfiche and miniprint. Subscribers can browse through Part S and decide whether or not they need and want the more detailed Part M. Publication delays are relatively short—about three months. It is interesting to note that the American Chemical Society, after a short trial, has decided not to publish its *Journal* in a similar dual format (see *Chem. & Eng. News*, 2 May 1977, pp. 26-27). When I questioned Grünewald about this, he expressed the opinion that the ACS had chosen the wrong type of publication to experiment with, i.e., its most broadly based and prestigious journal. He felt that the results of the trial would have been different if a more specialized publication such as the *Journal of Organic Chemistry* had been the subject.

Retrieval is a separate, albeit important, aspect of the technical information problem; Grünewald indicated that the preparation of the abstract and keywords for bibliographic files, abstract journals or other forms of data bank can (and should) be done by the author himself while he is writing the synopsis paper, rather than having it done later by someone else, i.e., by the staff of an abstracting journal.

Grünewald's enthusiasm for the synopsis journal was not matched by two other principal speakers. Indeed, one of them, F.W. Lancaster (School of Library Science, Univ. of Illinois), stated that anything less than a paperless journal is a "cosmetic treatment" of the problem and a stop-gap measure; the ultimate solution is a completely electronic system of scientific publication and information handling. Although, in his preprinted paper, he described a scenario for the year 2000, in his talk Lancaster predicted the disappearance of the printed forms of many primary and secondary scientific journals within the next decade.

John Senders (Dept. of Applied Science and Engineering, Univ. of Toronto) had a similar message, enlarging on his previously published advocacy of an on-line scientific journal, which he predicts will be the scientific journal of the future [*The American Sociologist* 11, 160 (1976), and *The Information Scientist* 11(1), 3 (1977)]. Noting that the cost of traditional journal printing and distribution has been increasing steadily while the cost of the components of an electronic journal has been gradually decreasing, Senders asserted that from a purely economic standpoint (even without including the economic value of the time saved in publication) the breakeven point between conventional publishing on paper and an on-line electronic journal would come around 1990 for a small (2900-page/year) journal with 2,500 subscribers or less. But for the bold step of setting up an on-line system covering all English-language scientific publications at once, the economic cross-over in favor of electronic publication already occurred five or six years ago! Senders reported that trials of four small electronic journals are in the process of being undertaken under NSF sponsorship, and a fifth may be sponsored jointly by NSF and the British Library Association.

Both speakers assumed (or predicted) that the scientific worker will ultimately have his own computer terminal in his institution—and even in his home, as well—connecting him to various data bases and to the scientific community at large, including "journal" editors. The preparation of a scientific report (it can hardly be called a "paper" under these circumstances!)

will then take place by using these facilities, and the writer's drafts will be electronically stored in his private data bank until he is ready to communicate the report to an editor. This would be done electronically, notifying the editor that the "manuscript" had been submitted and giving him access to it. The normal editorial procedures would follow—refereeing, advising the author of the referees' comments, etc.—by the same rapid electronic means of communication, until the report was finally accepted. "Publication" of the article would mean that it had been placed in the "journal's" electronic store, so that the subscribers could have access to it. It will be noted that this procedure would restore the "journal" to its literal etymological form; i.e., publication could be carried out every (or any) day, and the subscribers could find out what had entered the data bank daily rather than waiting for the weekly or monthly paper-printed issue to appear, as is now the case. Thus, while the quality of reports would be maintained by means of the traditional system of editing and refereeing, the long delays hitherto necessitated by these processes and by the printing, binding, and delivery of conventional journals would be avoided. Moreover, it would be possible for the reader to "browse" electronically through a report of this sort and to call up any part of the report for selective display—table of contents, conclusions, bibliography, figures, or raw data. A further advantage of an electronic journal is that it could eliminate the need for artificial restrictions on length or numbers of reports published, or it could at least relax these restrictions. Many more papers could thus be accepted by the first journal chosen by the authors, further reducing the delay in publication time.

Lancaster's talk went beyond the confines of the scientific journal and dealt with paperless communication systems in general—the realization of a paperless society in which the scientist uses his computer terminal for a multiplicity of purposes: as an electronic notebook to record his current research observations, as a means of building personal information files, as an instrument with which he can search the literature, as well as write, transmit, and receive text in connection with report preparation or communication with colleagues. Lancaster stated that his conviction concerning the inevitability of the paperless society and its feasibility in a much shorter time scale than he had originally estimated arose, in large measure, from his experience in designing and building a small prototype for one of the Federal intelligence agencies in 1973. Its success in filing, storing, and report writing was so great that a "Request for Proposal" to build a full-scale system for the agency was issued in late spring of this year. He pointed out that the technical information system used by Bell Labs and described at the meeting by W. Kenneth Lowry (BTL, Murray Hill) already partook of many of the features of paperless libraries. Further support for the Lancaster-Senders views is given, I may add, by the emergence of "Teletext" and "Viewdata"—which involve delivery of selections from among 800 to 70,000 pages of stored information, respectively, to the user on his home television receiver, the latter system also providing interactive instruction, message transmission, and computation (for further details on these new British developments, see article by N.M. Blachman, *ESN* 31-2:72).

As one might expect, vigorous discussion from the floor ensued, indeed the most lively exchange of the entire meeting. Grünewald defended the synopsis journal against the accusation that it was a stop-gap measure, and the Lancaster-Senders duo defended electronic publication against its characterization as gadgetry. Objections to the electronic journal were of both a psychological (the loss of the pleasure of flipping pages between one's fingers, loss of opportunity to read while traveling) and economic nature (possible loss of the advertising revenue that paper journals enjoy), not to mention some tongue-in-cheek objections ("What's the point of reading *Playboy* on line?"). My personal assessment of the debate was that the Elektronikers handled these objections very well and won out over the Gutenbergians by a respectable margin. Peace was declared, in my opinion, by Grünewald's statement that the synopsis journal is preparation for a good reception for the electronic or other different kind of future system which may be achieved in a decade or so.

Among the other topics covered at the meeting was a summary of the responses to modern information-user needs and new technological opportunities by the various national systems [US Defense Documentation Center, Alexandria, H.E. Sauter; Norwegian Center for Informatics, Oslo, H.K. Krog; Bureau National de l'Information Scientifique et Technique (BNIST), Paris, J. Michel; British Library, London, John Gray; Institut für Dokumentationswesen, Frankfurt, M. Cremer), and international systems [SCANNET-EURONET covered by K. Klintoe, Director DTO, Copenhagen; EURONET, also covered by G.W.P. Davies, Commission of the European Communities, Luxembourg (see also *ESN* 31-2:39); and the International Translations Center, described by its Director, D. van Bergeijk, Delft].

Many of these speakers emphasized, as did Lowry of Bell Labs, that their view of information systems has evolved from that of a library-like activity in a fairly relaxed partnership with science and research into a rather high-pressure, business-type activity that involves marketing, selling, legal problems, competition between public and private services, and political problems stemming from competition between the information services of different nations. Moreover, the demand has expanded from just science and technology to economics, statistics, products, technology- and information-transfer, and many other areas of society's interests. It is regrettable that illness prevented the meeting coordinator, Anton Disch of the Norwegian Center for Informatics, from presenting his thoughtful and stimulating paper, which touched on these aspects. Disch's paper also emphasized the characteristics and needs of the engineering problem-solver, who doesn't want to be buried under the landslide of citations and references that a modern information system can churn out, and hence spurns these in favor of sources that are less comprehensive and more readily available.

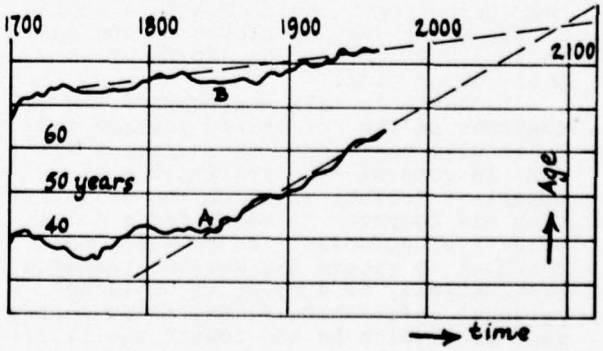
Although the two conference days were tightly packed with papers, the atmosphere was very informal and conducive to relaxed discussion, thanks to the ambience of the small meeting-hall decorated in native Norwegian folk style and just large enough to hold the approximately 75 participants. For fully relaxed participation in a meeting in Norway, however, one should be independently wealthy, what with self-service Cokes at 85 cents each.

The Conference Preprint bears the identification AGARD-CCP-225, and the Proceedings, when published, will be purchaseable from NTIS, Springfield, Virginia 22151, in microfiche or photocopy. (James H. Schulman)

THE FRENCH ACADEMY OF SCIENCE

"Tout change, tout passe, il faut être l'homme de son temps"—Talleyrand

On 15 November 1976, the French Academy of Sciences revised its statutes and regulations, the much needed change that was slow to come to fruition. From 1962 to 1975 several of its past presidents had tried to institute reforms to rejuvenate that "Old Lady" and to adapt her to the needs of modern science. Unfortunately, their one-year terms did not give them much time to push these reforms through. In 1975, the French President, the "protector of the Academy," formed a commission to look into possible reforms. Although this action was violently criticized by members of the Academy, most of the commission's proposals have been adopted by that august institution. The need for reforms that would rejuvenate the Academy is most effectively brought home when we consider the sketch below taken from a study by Professor A. Kastler, Nobel laureate in physics and academician, who, in 1972, looked at the trends in the mean age of the academicians at their election to that body (curve A on sketch below) and at death (curve B).



Curve A shows the mean age of academicians when elected to the Academy. Curve B displays their mean age at death.

He concluded that, should these trends continue, an academician would, on average, be elected in the year of his demise!

Let us begin by considering the Academy's role in French scientific life during the last three centuries. Then I will describe the reforms and their implications.

The French Academy of Science is one of five Academies constituting the "Institut de France"; the former was founded in 1666 by Colbert, the Commerce Minister of Louis XIV four years after the British Royal Society came into being. Colbert wanted to encourage the development of science in order to give French industry an edge on the competition. The Academy provided a forum for scientists and inventors to exchange ideas and to carry out scientific work in its laboratories. At its inception, there were only twenty-one scientific members. Several inventions were submitted for the Academy's consideration. While the Royal Society busied itself with what present-day science administrators might call "relevant" problems pertaining to arboriculture, naval architecture, and navigation, the French Royal Academy of Science (as it was then called) was commissioned by Louis XIV to investigate the difficult hydraulic problems resulting from the construction of the Versailles Palace, its gardens and fountains. Therefore, the academicians of that time became the first civil-service scientists.

The first journal in French included both literary as well as scientific articles and soon came under the aegis of the Academy, which used it to publicize its own work. The general public complained about the technical nature of the writings, and so Fontenelle undertook to write a special volume every year explaining scientific discoveries in terms understandable to the layman. It was the first popularization of science! During the 18th century the Academy was located in the Louvre, where it had at its disposal libraries and laboratories. It was comfortably endowed and so could offer attractive prizes.

Technology, far from being scorned as a lower form of scientific endeavor, was very much a part of the life of the Academy. In 1766 it considered a new type of fire engine and a glue-manufacturing process and it gave advice on the construction of mills in Lyon and on the erection of a bridge in Rouen. It devised a plan for supplying Paris with fresh water. That same year it offered a prize for the best way in which to light the streets of a large city like Paris. The well-known chemist Lavoisier received his gold medal for inventing the gas light. Also, in that year Lagrange was awarded a gold medal for his fundamental work dealing with the mathematical description of the perturbation of Jupiter's orbit by its satellites.

During the Napoleonic times at the beginning of the 19th century, the role of the Academy began to diminish. Engineering schools began to appear and became attached to the various ministries that turned to them for consultation. The Academy was no longer involved in carrying out research, for it lost its laboratory space and its Paris Observatory. It was made a part of the Institut de France. Few inventors presented their findings to the Academy. By the 20th century the Academy was overtaken by a constellation of specialized government agencies that dealt with the funding and administration of research and advised the government on scientific matters.

Until 1976 the Academy was divided into two divisions: Division I dealt with physical and mathematical sciences and Division II with natural and chemical sciences. In (I) there were five sections of six members each while (II) contained six sections with the same number of members per section. These eleven sections had the following headings: Geometry, mechanics, astronomy, geography and navigation, physics, chemistry, mineralogy and geology, botany, zoology, rural economy, and medicine and surgery. Each division was and still is headed by a secretary elected for life. Louis de Broglie, the well-known physicist, was the secretary of Division I until three years ago when he resigned because he felt that a younger man should carry out these duties. It is the secretaries who ensure the smooth running of the Academy.

Aside from these two divisions there were fourteen "free Academicians." Scientists were nominated under that category when there were no vacancies in the sections closest to their interests; mathematicians, physicists, chemists, etc., were found under this heading, which is no longer used. There

were six members that belonged to a section entitled "Applications of Science to Industry" (which has also been abolished) and twelve nonresident members. A nonresident member was one who lived so far from Paris that he was unable to complete the round trip from his home to the Academy within a day on horseback! Thus, the Academy was primarily a Parisian institution. This has also been changed as the French government hopes to eradicate the distinction between Paris and the remainder of France. Finally, there were twenty-eight foreign members and one hundred twenty foreign corresponding members.

The president of the Academy served a one-year term and the vice president automatically succeeded him. They were chosen alternately from Divisions I and II, the selection being based on seniority. Now the president must be elected alternately from the two Divisions, and his term may be extended to two years. The vice president no longer automatically succeeds him. As the years 1976 and 1977 cover the transition period, legislation has been enacted to carry through the aforementioned changes at least for these years. The number of Academicians has been increased from 100 to 130 and Divisions I and II have been retitled, respectively: Mathematical and Physical Sciences and their Applications; and Chemical, Natural, Biological and Medical Sciences, and their Applications. Division I now includes four sections: Mathematics, Physics, Mechanics, and Sciences of the Universe. Division II also includes four sections: Chemical Sciences, Cellular and Molecular Biology, Animal and Vegetal Biology, and Human Biology and Medical Sciences. There is no longer a limit on the number of members per section. When a member of one section dies, the vacancy can be filled by inducting a member into another section. Therefore the system is now much more flexible.

The *Comptes Rendus* is the official publication of the Academy; articles are reviewed and published very quickly. Critics have claimed that this rapid publication is primarily used merely to establish a publication date. An effort will be made to increase the quality of this journal (it now contains abstracts of papers in English).

On 25 April 1977 some 23 new members were elected. One of the provisions regarding the increase in the number of academicians was that half the number should not be older than 55. Among those nominated were the mathematician R. Thom (Field Medalist, 1958) and A. Lwoff and F. Jacob, both Nobel laureates in medicine. Under the new election process a list of candidates was established by the academicians and a vote was taken. Previously, a scientist had to submit his candidature and run the risk of being turned down. This is what happened to Irène Joliot Curie when she applied; the Academy is still misogynistic, for no woman has yet been elected.

Some think that the Academy has been eclipsed by other scientific bodies such as the Centre National de la Recherche Scientifique (CNRS), the Délégation Générale à la Recherche Scientifique et Technique (DGRST), the Commissariat à l'Energie Atomique (CEA), etc., while others feel that an impartial body of relatively young and well respected scientists could do much to counsel and guide the government, which is surrounded by a collection of agencies each having its own axe to grind. (Albert Barcilon)

MATERIALS SCIENCE

CONDUCTION IN NONCONDUCTORS

In the galaxy of colleges that join to form the University of London, Birkbeck College has a unique role. By its charter it accepts as undergraduates only those who also have full-time employment. Thus it is a serious effort in adult education for those who dropped out of the usual educational pattern leading to the university and wish to return. Courses are taught in the evening hours at Birkbeck, and there is no need to supply dormitory facilities.

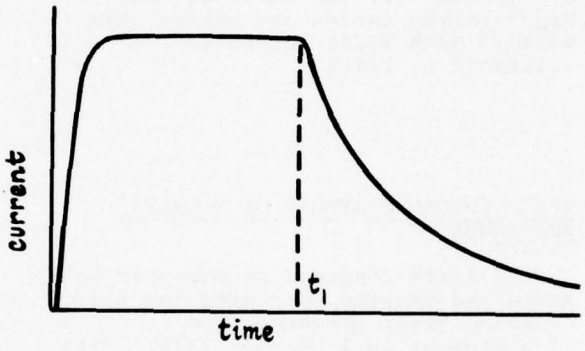
Fortunately for the graduate research programs, full-time students are permitted there. The Physics Department has a faculty of about ten people and covers a broad range of interests. J. Hirsch has been working for some years on the problems of electronic conduction in dielectric materials at electric fields that are high enough to begin to approach those producing breakdown.

Since good insulating materials have resistivities in the order of 10^{15} ohm-cm, straightforward direct-current measurements of their conductivity and Hall effect to determine the number of charge carriers, the sign of their electric charge, and their mobility is difficult. Most materials of practical interest are organic solids, and nearly all those being studied by Hirsch are, in addition, noncrystalline. The electron and hole mobilities are low, ranging from 1 down to 10^{-4} $cm^2/V\text{-}sec$. Thus, somewhat heroic measurement techniques are called for.

A routine measurement in the Physics laboratory involves forming a thin sample of dielectric between electrodes by evaporation and then bombarding the sample with a short pulse of electrons through one of the electrodes. Free electrons and holes are produced near this electrode; by altering the voltage applied to the sample, either the electrons or holes may be swept across to the other electrode. As the line of charge progresses, the external circuit registers a flow of current which stops when the charge reaches the electrode. By measuring the times of flight of the electrons or holes, their mobilities may be obtained.

In practice the current measured in the circuit does not stop abruptly but has a long tail as shown schematically in the accompanying figure. The time t_1 is taken as a measure of the transit time, and the tail is the portion of the curve beyond it. It is experimentally observed in a wide variety of amorphous systems that the shape of this curve is constant; that is, if the curves are normalized to the same t_1, the tails are the same. This can be explained by a model in which the electronic charge hops from trap to trap in the dielectric until it reaches the far electrode. The tail shows that there is a spread in the time necessary for this process to occur. The very low observed mobilities result from the fact that the charge is localized in traps for a large fraction of the transit time. In fact, the existence of numerous traps for both electrons and holes may be essential for good insulators.

The actual phenomena are complex, making it difficult to account in detail for temperature and field effects and the influence of electrode materials. Even the universal decay tail described above has been found by Hirsch not to hold in one organic compound, which gave very different decays depending on whether electrons were implanted from an external source or were injected from the electrodes by a sudden reversal of polarity across the specimen. However, the foundations of an understanding of the nature of conduction in dielectrics and in amorphous semiconductors has certainly been laid and is being vigorously explored in a wide variety of materials.



Current measured in the external circuit after injection of a short pulse of electrons into the dielectric through one electrode. The electron, or hole, charge is pulled across the dielectric by application of a high field.

Hirsch plans to concentrate on As_2S_3, both pure and doped with CdI_2. He has already measured mobilities and yields (that is, the total charge collected) and has suggested models for the effects of the dopant on these properties. He hopes to make this a model insulator with well-characterized material and high resistivity. At the same time it is a simple example of materials compounded with S, Se, or Te and called chalcogenides. The results should be relatable to the more complex, low-resistivity chalcogenides that are used in switching and memory applications of amorphous semiconductors. Hirsch also has available or is building a number of other measurement techniques to use on the same materials, including photoinduced Hall effect, thermally induced conductivity peaks,

and charge buildup in materials after applying a voltage pulse.

While the physics of the conduction processes in these dielectric materials may be related to that in other amorphous materials, the long-range goal of the work done by Hirsch is aimed at understanding prebreakdown currents and the eventual electronic breakdown of insulating materials in condensers and high-voltage cables. It had been a rather lonely field, but the boom in the study of amorphous materials in general and the recent development of concern over the unreliability of high-tension cables are making this work of much wider interest. (Clifford C. Klick)

XIXTH CONGRESS AMPERE ON MAGNETIC RESONANCE

The XIXth Congress on Magnetic Resonance and Related Phenomena was held in Heidelberg, Germany, from 27 September to 1 October 1976. Over 230 papers were presented, consisting of 11 "Invited Papers" (40 min plus 5-min discussion), 7 "Introductory Papers" (25 min plus 5-min discussion), 99 "Submitted Papers" (15 min plus 5-min discussion), and 122 "Specialized Papers" (10 min plus 5-min discussion). The invited papers were given nonconcurrently whereas the remaining were organized in parallel sessions. The scientific participants represented 25 countries.

After the opening ceremony, invited papers were presented on the magnetic properties of superfluid ^{3}He, triplet states of electron-donor complexes, and coherent phonon emission by spatially-phased spins (E.L. Hahn and R. Wilson, Physics Dept., Univ. of California, Berkeley). This last paper described an interesting new method for generating phonons by carefully matching the phase between phonons and electron spins. This is accomplished by means of a sinusoidally-phased array of spin polarization, achieved by the application of inhomogeneous magnetic-field pulses.

In the afternoon there were parallel sessions of both submitted and specialized papers. The submitted papers dealt with nuclear magnetic resonance (NMR) and ^{3}He, charge-transfer complexes, and radicals; the specialized papers were grouped around NMR double resonance and rotating frame experiments, motional effects on lineshapes and relaxation times, magnetic resonance methods, paramagnetic ions, and magnetic ordering.

An introductory presentation by F. Waldner (Physik-Institut der Universität Zürich, Switzerland) described the combining of spin-decoupling techniques with sample-spinning techniques at the magic angle to reduce the linewidth and determine the chemical shift anisotropy. It was followed by two papers describing, in solid ^{3}He, T_1 and T_2 measurements (T_1 and T_2 are spin-spin and spin-lattice relaxation times) and the observation at temperatures around 1 mK of multiple echoes that are explained by nonlinear effects due to the demagnetizing field of the spin magnetization (M. Bernier and J.M. Delrieu, SPSRM CEA, Gif-sur-Yvette, France). In parallel, an introductory paper described T_1 measurement of polypeptides containing glycine, alanine, valine, and leucene and explained the results in terms of reorientations of the NH_3 and CH_3 groups (E.R. Andrew, R. Gaspar, T.J. Green, and W. Vennart, Dept. of Physics, Univ. of Nottingham, UK). Following were talks describing the determination of charge transfer in phenanthrene PMDA by a calculation of the fine-structure tensor, measurements of frequency and temperature-dependence of proton T_1 in salts of RB^+ and $TCNQ^-$, determination of electron-spin multiplicity of radical ion pairs by chemically-induced dynamic nuclear polarization, the application of electron-nuclear triple resonance techniques to biradicals, and the interpretation of ELDOR measurements of relaxation times of peroxylaminodisulfonate in water solutions.

A number of papers applied electron spin resonance (ESR) and NMR measurements to radicals and biological systems (e.g., starch, urea, sol-gels, macromolecules, halophilic bacteria) as well as some describing the effects of molecular motions on linewidths and relaxation times. Quite a few presentations described new techniques and apparatus for doing such diverse experiments as separating overlapping ESR lines, studying domain-wall resonance in magnetic materials, and simultaneously spin-locking two or more

groups of spins. Papers were presented on magnetic systems that described relaxation of paramagnetic ions, ESR measurements in garnets and in Mn-doped $KMgF_3$, and NMR spin-echo measurements in FeSi single crystals.

An invited paper dealt with the application of ESR and Mössbauer experiments to the study of quasi-two-dimensional magnets (F. Waldner, Physik-Institut der Universität Zürich, Switzerland), and another invited paper described the observation by ESR of paramagnetic centers in one-dimensional conjugated polymers (D. Bloor, Physikalisches Institut, Universität Stuttgart, FRG). These were followed by three parallel sessions of submitted papers—on rare earths, liquid crystals, and shielding tensors. The rare-earth presentations were devoted largely to ESR in determining site symmetry of such systems as Ce^{3+} in CaF_2 and Yb^{3+} in SrF_2, as well as on the observation of magnetism in substances like $LiTbF_4$. Papers on liquid-crystals involved multiple-pulse techniques and relaxation-time measurements to study both static and dynamic properties, while those on shielding-tensors consisted largely of the use of multiple-pulse techniques. Reported here was the first determination of a double-bond tensor for carbon-carbon double-bond (E.K. Wolff, R.G. Griffin, and J.S. Waugh, Dept. of Chemistry and Francis Bitter National Magnet Laboratory, MIT, Cambridge), as well as a paper demonstrating that the spin-temperature hypothesis can be applied to a string of discrete rf pulses (W.K. Rhim, D.P. Burum and D.D. Elleman, Jet Propulsion Lab, California Inst. of Technology, Pasadena).

A group of submitted papers on paramagnetic centers, liquid crystals, and spin-imaging were followed by contributed papers on paramagnetic centers, liquid crystals, rotating NH_4^+ ions, NMR in metals, one- and two-dimensional systems, paramagnetic ions, and NMR relaxation in solids. The presentations on paramagnetic centers, consisting entirely of ESR observations, were preceded by an introductory paper describing a theoretical method for getting hyperfine tensor components. The talks on spin-imaging included three fascinating presentations of biological interest. The first presented line-scan pictures of spin density in a magnetic-field gradient which, for the first time, revealed recognizable anatomical detail in a live human (P. Mansfield and A.A. Maudsley, Dept. of Physics, Univ. of Nottingham, UK). The second, on field-focusing NMR (FONAR), described the first NMR image of a tumor in a live animal (R. Damadian, L. Minkoff, M. Goldsmith, M. Stanford, J. Koutcher, and Pioneer Mouse II, Biophysical Lab, State Univ. of New York, Brooklyn). Because of the non-invasive nature and low radiation hazard of NMR, it appears that the NMR imaging has great potential in medicine.

This was followed by a paper measuring the ^{31}P chemical shift tensor in oriented dipalmitoyllecithin, an essential phospholipid component of most bioligical membranes, in which the conformation of the molecule was determined (R.G. Griffin, L. Powers, J. Herzfeld, R. Haberkorn and P.S. Pershan, Francis Bitter National Magnet Lab, MIT, Cambridge). Later presentations on paramagnetic centers, liquid crystals, and paramagnetic ions consisted largely of ESR and ENDOR determinations of site symmetries and structures. Papers on NH_4^+ included studies of rotational motions of the NH_4^+ ion, while those on metals were characterized by studies of hydrogen diffusion in transition metal hydrides.

An invited paper discussed different aspects of acoustic nuclear and electron spin echoes in solids (V.A. Golenishchev-Kutuzov, N.K. Solovarov, V.F. Tarasov, Kazan Physico-Technical Inst. Academy of Science, USSR), which has the advantage over conventional NMR and ESR of not being limited by the skin-effect in metals. A second invited talk (C.P. Slichter, Univ. of Illinois, Urbana) discussed NMR studies of dilute alloys of magnetic atoms in nonmagnetic hosts (e.g., Cu) which measured the temperature-dependence of the magnetization at different sites in the vicinity of the Kondo temperature. These were followed by sessions of submitted papers on metals, phase transitions, and NMR relaxation in liquids. The papers on metals involved a potpourri of different techniques for studying metals: NMR, superconducting quantum interference devices (SQUID), Mössbauer effect, and β-radiation anisotropy. The last technique (P. Heitjans, A. Koerblein, H. Ackermann, D. Dubbers, F. Fujara, M. Grupp, and H.-J. Stoeckmann, Physikalisches Inst., Heidelberg, FRG and ILL, Grenoble,

France) is a particularly interesting new method of measuring T_1 in ^{7}Li-Mg alloys by measuring polarized β-radiation from ^{8}Li produced by the capture of thermal neutrons. This technique has the advantage that it requires no rf field to measure diffusion. Talks on phase transitions included studies of structural transitions as well as order-disorder transitions. Many papers of biological interest were included in the section on liquids. These focused on studies of water interacting with surfaces (e.g., muscle tissue) or with large molecules (e.g., DNA).

An invited paper surveyed the main lines of hyperfine investigation studies (Prof. Dr. J. Christiansen, Physikalisches Inst. der Universität Erlangen-Nürnberg, Erlangen, FRG) by perturbed γ-γ angular correlations, with applications to the determination of internal electric field gradients, diffusion of lattice defects, and interactions between impurity atoms and lattice vacancies. A second invited presentation surveyed the quantum tunneling effects of rotating CH_3 and NH_4 groups in molecular solids. These were followed by submitted papers on tunneling, quadrupole interactions, and conduction electron effects in metals. Among the techniques used were NMR, ESR, nuclear quadrupole resonance, and nuclear acoustic resonance. In sessions of contributed papers tunneling, quadrupole effects, conduction electrons, ENDOR, dynamic nuclear polarization, triplet states, mixed ESR, rotating NH_4^+, metals, paramagnetic complexes, phase transitions, and NMR relaxation in liquids were covered. The quadrupole presentations were preceded by an introductory paper describing double quantum coherence and its application to high-resolution deuterium NMR in solids.

Both were on optical detection of magnetic resonance—the first being applied to semiconductors and the second to the detection of photo-excited triplet states of poly-atomic molecules. These were followed by three submitted papers on optically excited states, rotating-frame NMR and double-resonance, and spin-phonon interactions. Those rotating-frame NMR included a number of interesting talks on double-resonance and multiple-pulse techniques. One paper described a new double-resonance method for the detection of weak-spin diffusion (H.T. Stokes and D.C. Ailion, Dept. of Physics, Univ. of Utah, Salt Lake City) and its application to the detection of Ag diffusion in AgF. Also included was a paper describing a new method for using field modulation to reduce the dipolar coupling which can be applied to uncovering chemical shift and heteronuclear coupling information which is obscured by homonuclear coupling (C.S. Yannoni and H.-M. Vieth, IBM Research Lab, San Jose, CA). Most of the presentations on spin-phonon interactions involved applications of ESR to the study of phonons in solids.

The last session of the Conference consisted of submitted papers on semiconductors and ESR, NMR relaxation in solids, and Jahn-Teller ions. Included were papers describing the application of NMR relaxation measurements to one- and two-dimensional antiferromagnets and an introductory talk describing two-dimensional spectroscopy—a method for resolving complex proton and carbon spectra.

The proceedings of the Conference have been published in *Magnetic Resonance and Related Phenomena*, H. Brunner, K.H. Hauser, and D. Schweitzer (eds.), Groupement Ampère, Heidelberg-Geneva, 1976. (David C. Ailion, Dept. of Physics, Univ. of Utah, Salt Lake City)

THE AGARD SYMPOSIUM ON LAMINAR-TO-TURBULENT TRANSITION

The Fluid Dynamics Panel (FDP) of the Advisory Group for Aerospace Research and Development (AGARD), held a (by invitation only) "Symposium on Laminar-Turbulent Transition" in Lyngby, Denmark, on 2-4 May 1977. Since the Symposium was an outgrowth of activity of the US Transition Study Group established in 1969 under the chairmanship of Prof. Eli Reshotko of Case Western Reserve University and the later-established European Working Party on Transition in Boundary Layers, the papers presented represent, in a way, the fruition of the activities of these two groups and the considerable monetary support generated by them. Also worthy of assessment is a method of attacking a problem involving "blue ribbon" study

groups that are influential in the dispensing of research funding.

Though the precise mechanism of transition from laminar to turbulent flow is not fully understood, the process immediately preceding transition is somewhat clearer. It is generally accepted that a laminar boundary-layer flow becomes unstable at a sufficiently large distance downstream from the leading edge of the boundary layer. The instability manifests itself in the growth of self-excited wave-like disturbances that are timewise and spacewise periodic, and propagate in the direction of the flow. Somewhat after this point is reached, transition to turbulence ensues. Delaying transition in the boundary layer (the region in which viscous forces play a role) would result in reduced drag.

The meeting started with an introductory review lecture by M.V. Morkovin of the Illinois Institute of Technology. The papers that followed fell into groupings of Boundary Layer Stability and Transition to Turbulence.

Of some twelve papers in Boundary Layer Stability, seven were concerned with linear stability (the stability of the boundary layer with respect to infinitesimal amplitude disturbances) and included such topics as the use of linear stability theory to predict transition to turbulence, mathematical techniques of stability calculation, three-dimensional boundary layers, rotationally symmetric flows, and nonparallel boundary-layer flows with pressure gradients. The results of studies in boundary-layer stability with heating at the boundary by A.J. Strazisar and E. Reshotko of Case Western Reserve University were presented, and it was shown that heating the boundary layer tends to stabilize the boundary layer in water. The studies, performed in a low-turbulence water tunnel, included the effects of uniform and nonuniform wall temperatures; the growth rates of oscillating-ribbon-induced disturbances were obtained directly with hot-film anemometry. The way in which the boundary-layer instability is delayed by heat addition at the boundary is that the velocity distribution is altered. Since the viscosity of water decreases with an increase in temperature, a temperature gradient at the boundary results in a viscosity gradient that so affects the velocity distribution (it makes it convex with no inflection point at the boundary) that the minimum critical Reynolds number for instability is increased, thus delaying the onset of turbulence.

Among the papers in nonlinear boundary-layer instability were analytical and numerical investigations of the evolution of an initially linear disturbance. T. Herbert of the University of Stuttgart compared results from asymptotic (Landau) theory with those from a direct Fourier expansion of the complete equations and found that the asymptotic theory can give misleading results at other than very small disturbance amplitudes. Papers by J.W. Murdoch and T.D. Taylor of the Aerospace Corp. and H. Fasel, H. Bestek, and R. Schefenacker of the University of Stuttgart presented the results of numerical experiments on two-dimensional-disturbance evolution. A paper by P. Huerre of Leeds studied the nonlinear instability of free shearing layers and found that nonlinear effects can be more important than viscous effects in the critical layer; the result is not very surprising in view of the fact that disturbance Reynolds stresses can easily exceed viscous stresses. A paper by Prof. F.X. Wortman of the University of Stuttgart reported on observations of the evolution of two-dimensional unstable disturbances in a laminar boundary layer; the disturbances were produced by an oscillating ribbon, and the resulting waves were visualized in the water tunnel by using hydrogen-bubble techniques. Three-dimensional disturbance structures were observed forming on the two-dimensional waves; the formations were in two layers and seemed to lie respectively above and below the critical layer of the boundary layer. The motion pictures showing the visualized disturbance were roundly applauded and much discussed.

The session on transition description contained seven papers which, in part, were concerned with the response of the boundary layer to external excitation. The ordinary boundary-layer-stability problem describes self-excited disturbances within the boundary layer; the instabilities can be conceptually oversimplified to be analogous to resonances in a free vibration. Many experiments have been performed in which the unstable disturbances are excited by an oscillating

ribbon or an external sound source. Of course, the analysis of such a situation is properly no longer that of the self-excited disturbance. Some experiments by D. Arnal, J.C. Juillen, and R. Michel of the Office National d'Etudes de Recherches Aérospatiales (ONERA-CERT), Toulouse, France, concerned a self-excited flow, and calculations using turbulent transport equations were in fair agreement with the observed mean flow characteristics of the turbulent boundary layer. A corresponding experiment by R. Houdeville, J. Cousteix, and A. Desopper of ONERA-CERT concerning an externally, periodically excited boundary layer showed poor agreement between the observed and predicted mean flow in the turbulent regime. In a paper by P. Gougat and F. Martin of the CNRS-Meudon (France), the results of an experiment investigating boundary-layer instabilities and transition over a statically and dynamically perturbed boundary were presented. Since the boundary-disturbance wavelength and frequency were much longer and lower, respectively, than those of a self-excited disturbance, the dominant disturbance observed was the self-excited one.

An interesting mathematical model of a boundary layer excited by freestream disturbances was presented by H.L. Rogler of the University of Southern California. Rogler modeled the boundary layer in terms of two layers of uniform vorticity with the same combined momentum thickness as that of the ordinary laminar boundary layer. The freestream disturbance was modeled as a uniformly spaced array of rectangular vortices outside the boundary layer. It was found that the forced oscillations had the same phase velocity and wavelength as the driving disturbances. There also existed natural oscillations of wavelength and phase velocity different from those of the driver but of the same frequency. The effect of apparatus boundary-layer noise on the early transition of the supersonic wake from a transverse circular cylinder was studied by H. Burnage and J. Gaviglio of the Institute of Statistical Mechanics of Turbulence in Marseilles. It was found that, when the noise radiated by the wind-tunnel boundary layers was more intense, the transition in the wake of the cylinder occurred sooner.

The effect of wall heating on boundary-layer transition in water was studied by S.J. Barker and C. Jennings of UCLA and Rockwell International, respectively. In a carefully constructed experiment, a boundary layer inside a 10.2-cm-diameter tube, 6.1 m long was subjected to heating at the tube's boundary. With no wall heating, boundary-layer transition Reynolds numbers of 10 million were obtained. Boundary heating produced results in agreement with theory up to overheats of 10°F; at higher overheats, delays of transition fell below theoretical predictions until, at an overheat of 35°F, the highest transition Reynolds number, 42 million, was obtained whereas the theory predicted transition Reynolds numbers in excess of 200 million. The experiment was conducted at the Colorado State Engineering Research Center so that the Horsetooth Reservoir would be available as a water supply for the boundary-layer test section. A large settling chamber containing filters and honeycomb mesh was provided upstream of the test section to reduce the level and scale of turbulence in the test. Hot-film anemometry was used to measure mean and rms flow velocities.

In a session devoted to prediction of transition, various empirical methods, including second-order closure schemes, were presented. Finally, in a session devoted to experimental methods, techniques for reducing external excitation of the boundary layer by tunnel noise and infrared detection of transition regions were presented.

In all, with few exceptions, there were no surprises or unexpected revelations among the papers. It does not seem to this reviewer, that select committees working in closed sessions without disseminating the results of their deliberations or requesting inputs from a broad spectrum of workers in the respective fields can be effective in "pushing back the frontiers." If anything, the result is a generally lackluster symposium. (Martin Lessen)

ONRL REPORTS

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OCEAN SCIENCE

WATER-WAVE DYNAMICS AT CAMBRIDGE UNIVERSITY

The Department of Applied Mathematics and Theoretical Physics of the University of Cambridge deals with teaching and research in three wide areas: the mechanics of fluids and solids and its applications (geophysics, engineering, biology); astrophysics, general relativity, and plasma physics; and quantum physics and its application. My visit focused mainly on the first area, and even then my interests led to discussing just problems of a geophysical nature. If I limit myself to that context, I can subdivide the work presently found in the Department into: study of water waves, oceanography, turbulence in the presence of stratification, environmental and geophysical fluid dynamics, and the study of nonlinear wave motions in geophysical fluids.

In this note I shall discuss research in water waves and leave the discussion of some of the other topics for additional notes.

M.S. Longuet-Higgins holds the Royal Society Research Professorship and is also a member of the Institute of Oceanographic Sciences. He is interested in some of the very difficult phenomena associated with nonlinear water waves and wave breaking. This area of research is important for a number of reasons: it has been shown that the drag exerted by the waves on the atmospheric flows as well as the transfer of gas, momentum, and energy across the air-water interface depends critically upon the wave state of the free surface; these phenomena, although understood qualitatively, are not yet well enough grasped quantitatively. Breaking waves play an important part in mixing the upper ocean layers, and some of their energy can be fed into water currents. Knowledge of these nonlinear waves has considerable bearing on the optimum design of structures, both nearshore and offshore. Last but not least, wave energy can be piled up near the shore in the narrow region called the surf zone, where mean circulations and sediment transport due to erosion or accretion can radically change the morphology of a coast.

At present there is no "good" theoretical model for nonlinear water waves. A century ago, the well-known English engineer and inventor F.W.S. Stokes did some remarkable work on water-wave dynamics. Expansions that bear his name and attempt to model the wave profile diverge as soon as a nondimensional measure of the wave curvature (wave amplitude times wave-number) exceeds 0.1. This breakdown can be explained by visualizing an initially sinusoidal wave deforming (while still remaining symmetric) in such a way that the crest tends to sharpen while the troughs flatten. Representation of this sharpening requires a large number of terms in the Stokes expansion. To obviate this problem, Longuet-Higgins uses an "inner" representation near the crest and an "outer" one for the troughs. The interested reader is referred to "Theory of the Almost Highest Wave: The Inner Solution," by Longuet-Higgins and one of his students, Mr. M.J.H. Fox [*J. Fluid Mech.* 80, 721-742 (1977)].

Another interesting property was discovered by Longuet-Higgins. He found that, when the nondimensional momentum, mass, energy, and phase speed of a solitary wave (a wave having a single crest) are plotted against the relative wave height (measured in terms of the local depth), they exhibit a maximum when the relative wave height is near unity. He argues that an instability must set in as this maximum is approached. This observation assumes that the solitary wave remains symmetrical; in practice, as a wave shoals, i.e., as the local depth decreases, it tends to become asymmetrical and eventually breaks. The breaking process is a complex one, and several types of wave breaking have been recognized. The plunging breaker is one in which the forward face of the wave develops a jet-like tongue that plunges forward with great force, entraining large quantities of air. This vigorous process modifies the wave radically. A much gentler process is found in a "spilling" breaker, which causes little alteration to the wave shape, the wave proceeding shoreward with a plume of foam on its forward face. The models generated by Longuet-Higgins can be used to represent this

last type of wave dynamics in the surf zone [Longuet-Higgins and Fenton, "On The Mass, Momentum, Energy and Circulation of a Solitary Wave. II," *Proc. Roy. Soc. Lon.* A. 340, 471-493 (1974)].

Longuet-Higgins and one of his students, Dr. E.D. Cokelet, are working on efficient and accurate numerical schemes for modeling these flows. This work is motivated in part by relaxing some of the assumptions introduced in the theoretical models. In natural conditions the occurence of a steady, steep wave is somewhat exceptional. Even symmetric waves tend to become unsteady and asymmetric long before their energy reaches the theoretical maximum. They developed an ingeneous numerical scheme that assumes that the motion is periodic in space and is irrotational, i.e., a fluid particle does not possess any spin ["The deformation of Steep Surface Waves on Water, I: A Numerical Method of Computation," *Proc. Roy. Soc. Lon.* A. 350, 1-26 (1976)]. Under these conditions a velocity potential, i.e., a scalar function whose gradient is the particle velocity vector, can be introduced. They use the velocity potential in place of the vertical coordinate. By introducing a complex transformation, they map the free surface into a closed curve and transform the numerical problem into a much simpler one. They use 60 "particles," which they follow in time as the wave steepens. The particles have a tendency to congregate near points of large surface curvature which is precisely where they are needed for computational accuracy. According to Longuet-Higgins, the tongue of fluid or jet that develops at the moment of breaking must be influenced by surface tension and air currents, both of which could be represented in the model if need be. To test some of the numerical results, Prof. Longuet-Higgins, Mr. N.D. Smith, and Dr. N. Hogben made some high-speed film (500 frames per sec) in one of the towing tanks of the National Physical Laboratory at Teddington. The film confirmed that the free surface remains smooth and rounded until after overturning takes place.

I venture to say that wave breaking is one of the important unsolved problems in fluid mechanics, and Longuet-Higgins and his students at Cambridge University are close to unraveling this complicated phenomenon.
(Albert Barcilon)

INSTITUT FÜR SCHIFFBAU, UNIVERSITY OF HAMBURG

The occasion of the 25th anniversary of the Institut für Schiffbau (IfS) at the University of Hamburg (*ESN* 31-6:248) was celebrated by a Colloquium held at the Institut. The IfS is highly regarded by practitioners in Naval Architecture, and so it is not surprising that invited speakers came from as far away as Japan for the meeting.

The colloquium opened with an address by the Director of the IfS, Prof. O. Krappinger, who reviewed the development of the Institut and its attainments over its 25-year history and extolled the pivotal role of its first director, Prof. G.P. Weinblum.

On the evening of the first day of the Colloquium, a banquet in the Rathskeller of Hamburg provided the social focus of the 25th Anniversary celebration.

The technical presentations began with "Dynamic Programming Applied to Optimal-Life Prediction for Ships" by Prof H. Benford (Univ. of Michigan) and E. Brown (US Coast Guard) that was concerned with deciding when to retire and replace an existing ship on economic grounds. Factors considered in the projections were depreciation, obsolescence, increased upkeep, greater efficiency of the replacement, and changing conditions in the political and economic environment such as tax laws, etc. Hopefully, the buyer of an old ship and the seller of it would be operating with different dynamic programs.

A paper "On Terminal Conditions for Collision Avoidance between two Ships" by Prof. T. Miloh (Univ. of Tel Aviv) and Dr. S.D. Sharma (IfS) adapted the planar pursuit-evasion differential "Game of Two Cars" (R. Isaacs "Differential Games" John Wiley 1965) to ship-collision avoidance. The game consists of two circular cars (one pursuer and one evader) maneuvering in a plane; the velocity of the pursuer is faster than the velocity of the evader but the turning radius of the evader is smaller than that of the pursuer. The game has been refined by substituting elliptical for circular vehicles while including the effects of acceleration control and speed loss in a turn to simulate the ship dynamics more realistically. A "capture criterion" which relates the significant

parameters of speed ratio and turning-rate ratio of the pursuer and evader to the min-max miss distance was presented.

"Roll Oscillations Including Nonlinear Effects" by Prof. O. Grim (IfS) principally concerned the effect of the periodic variation of wetted area of the hull at roll angles in excess of 10°, although the effect of trailing vortex separation at the bilge keels was mentioned. Since the rolling motion of a ship is weakly damped, the resonant rolling oscillations are often of high amplitude. However, the roll-damping force increases more rapidly than linearly with roll amplitude, and so the resonance peaks are not so high as they would be in the linear case. The effects of nonlinear inertial and restoring forces were shown to be of small significance, resulting mainly in a small shift of the natural roll frequency.

A review paper "Aerodynamic Forces on Ships" by Prof. H. Thieme (IfS) considered the effect of wind on the speed, stability, and maneuverability on a non-wind-driven vessel. In addition, previous methods of modeling wind forces were extended to include effects of storms.

A paper by Profs. T. Inui and H. Kajitani (Univ. of Tokyo) entitled "A Study of Local, Nonlinear Effects on Ship Waves and Wave Resistance" formulated the ship-wave problem in terms of a wave propagating on a flow distorted by the presence of the ship. It was found that calculated drag characteristics compared well with towing tank data for a series of different beam-length ratios.

"Cavitation of Hydrofoils" by W.H. Isay and L. Lederer (IfS) applied the results of the theory of stability and dynamics of a single bubble in a spherically symmetric pressure field to calculate the cavitation pattern in the low-pressure region on the upper (suction) side of a hydrofoil. In the calculation, a size distribution and number density of bubbles obtained from an experiment using light-scattering techniques were used. In a related paper, "The Cavitating Tip Vortex of a Propeller and the Resulting Pressure Oscillations" by E.A. Weitendorf (IfS), the effect of cavitation-induced pressure fluctuations in the region of the propeller was studied. The cavitating vortices were modeled as hollow (coreless) vortices that had a superposed wave structure to represent the nodal structure (stationary with respect to the propeller blade) observed in the experiment. The results of the theory correspond to observation.

A remarkable calculation of the drag of a ship was presented in a paper "Scale Effect on Propulsive Performance of a Full Ship," by Profs. K. Nakatake and R. Yamanaki (Kyushu Univ., Japan), who mathematically modeled the actual hull form of an ore carrier (length = 302 m, dwt = 162,400 tons) along with an infinitely bladed propellor for the full-scale case as well as 4-, 8-, and 12-m-long models. The detailed theory, including friction effects, produced results that compared well with self-propelled-model and prototype tests.

Papers on "Strength Calculations and Testing" by H. Petershagen (IfS) and "Remarks on the Possibilities and Limits of Vibrational Analysis Applied to Ships" by H.G. Payer (German Lloyd) applied finite-element techniques of calculating stresses and natural vibration frequencies along with laboratory and full-scale tests, to relevant ship-oriented problems, while a paper "New Developments in Ice Technology" by J. Schwarz [Hamburg Ship Model Basin (HSVA)] covered the use of ice with scaled physical properties in the ice towing-tank facility of the HSVA as reported previously. (*ESN* 31-6:248).

The final paper of the Colloquium, "Flow Resistance in a Discontinuum" by Prof. K. Wieghardt (IfS), discussed theoretical and experimental results of an investigation of the deformation of a discontinuum such as sand with or without an admixture of water. The subject is of interest to soil mechanicians and has application in earthworks, hydraulic structures, formation and maintenance of channels and harbors, etc. For the pure-sand medium, increasing rates of deformation result in lowered deformation resistance because static dry friction is generally higher than kinetic dry friction; any further increase in deformation rates, however, involves dynamic effects that tend to increase the deformation resistance. For a sand-water mixture, sand must dilate to a looser packing to enable motion, thereby drawing more water into the intergranular spaces. If there is not a sufficient water surplus, the free water surface is drawn into the

mixture, resulting in capillary forces that affect the resistance to deformation; a chemical additive that reduces surface tension also reduces this effect drastically.

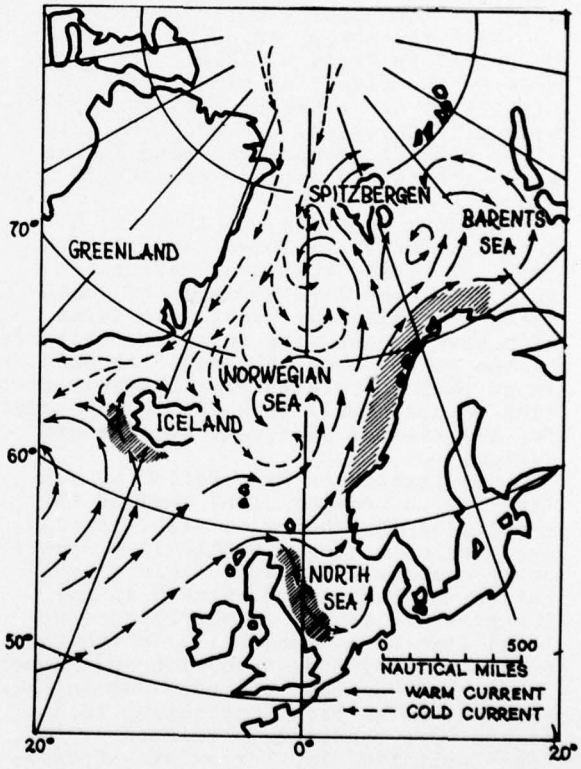
In all, the meeting dramatically illustrated the impact of modern analytical and technological tools on naval architecture. (Martin Lessen)

OCEANOGRAPHY IN BERGEN

The Geophysical Institute at the University of Bergen houses three sections: geomagnetism, meteorology, and oceanography. In this article I will describe some of the ongoing work in the last section. Oceanography at Bergen goes back to the turn of this century and has been associated with such well-known oceanographers as H. Hansen, H.U. Sverdrup, and Professor H. Mossby; the last, whom I had the pleasure of meeting, officially retired some years ago but still maintains an active university life. Bergen can boast one of the largest Norwegian groups dealing in physical oceanography; the director of this group is elected for a two-year term, and at present Docent A. Foldvik fills the position. There are 13 faculty members with three holding the rank of professor, 20 undergraduates, and about 10 graduate students. Research in the Department of Oceanography focuses mainly on physical oceanography and can be roughly divided into five areas.

The first of these, a multidisciplinary research project involving several Norwegian institutions, deals with studies pertaining to the Norwegian Coastal Current. The project was initiated in 1974, and at present three Norwegian research councils provide what Professor M. Mork calls "catalytic money" to the tune of some $200,000 per year. The bulk of the scientists involved, as well as ship time, are supported by the various Norwegian institutes and universities. The main objective of this work is "to increase our knowledge of the structure and dynamics of the Coastal Current and the relationship between the physical, chemical, biological, and marine-geological conditions in Norwegian coastal waters." As such, it is a continuation of earlier research work started some 70 years ago by B. Helland-Hansen and F. Nansen. In addition to the primary objectives quoted above one finds a number of subsidiary objectives, some related to fundamental research while others have a more applied character. The main ones can be summarized as: collaboration in coastal-water research among various institutions, optimum use of research resources, and interdisciplinary character resulting in simultaneous investigations of some facets of the same problem.

The Norwegian Coastal Current is a continuation of the Baltic current (see sketch) and, as its name implies, is found along the entire Norwegian coast. The inflows from the Baltic and the Norwegian coast amount to 500 and 400 km^3/year, respectively.



Surface currents in the Northeast Atlantic. The shaded areas show the position of the main spawning grounds.

To these one must add a large amount of water from the Atlantic and the North Sea as well as from the Norwegian Sea that is entrained into the current by turbulent mixing. Conditions in the Coastal Current are very variable in time and space and are of vital importance to fisheries because the Current is the main artery for fish-egg and small-fry transport from the spawning areas to the nursery grounds. Also high primary production (phytoplankton and zooplankton) is found in coastal waters and is of extreme importance for sustaining fish growth. There is therefore a strong correlation between the dynamical and biological character of the Current. Although such a correlation is not entirely understood at present, it is believed to be tied to the current dynamics and to the stability of the underlying water masses that are entrained by the Current and carry with them rich nutrients. There are several mechanisms capable of driving such a coastal current. The most likely one and the one that undergoes the smallest amount of fluctuation results from the freshwater run-offs from Norwegian fjords and the relatively fresh Baltic Sea. The Current is also affected by wind stresses and bottom topography. The wind-stress drive can cause changes to take place over short periods of time and over short distances and is responsible for much of the Current's variability in space and time.

In Bergen, Dr. G. Furnes of the Geophysical Institute is the coordinator for the entire project; Mork and his students, as well as one or two other faculty members, are involved in some of the research problems dealing with this Current. Mork, who recently spent six months at Yale University, is investigating some simple analytical and laboratory models that idealize conditions found in nature without losing the essence of this problem. An experiment is presently underway in which fluid is rotated between two concentric cylinders to model the earth's rotation. A lighter fluid injected via the upper portion of the inner cylinder provides the drive to model the freshwater inflows from fjords, rivers, and the Baltic. The lighter fluid forms a front-like wedge that slowly moves radially outward, producing complex zonal and meridional currents. In the analytical model, Mork deals with a Cartesian geometry in which a straight coast runs North-South and along which a line-source of fluid is prescribed. The model is assumed to be stationary. The theoretical predictions are of the correct order of magnitude. Mork has considered both a constant entrainment coefficient and one that depends upon a measure of the fluid's vertical stabilty and has found very little change in his final results. He feels that the foregoing model is correct for the "average" description of this Current. He has also been interested in tidal mixing in fjords and estuaries and in wind and tide effects in stratified oceans. Atmospheric-pressure oscillations as well as time varying wind stresses can generate internal oscillations that may grow and thus play an important part on or near continental shelves.

Dr. J. Buckley, from the University of Vancouver, who is a postdoctoral fellow at Bergen University, is investigating several semiempirical models of the Coastal Current and is looking at volume transport and salt transport.

The second area of research deals with analytical work of geophysical fluid-dynamical character that is not related to the previous area of research nor to the next three to be discussed. Dr. T. Gammelsrød, who spent nine months at the Graduate School of Oceanography at the University of Rhode Island with Professor M. Stern, has been looking at Langmuir circulations in the oceans and/or in the atmosphere when rotation is present. Some of his work has appeared in *Journal of Geophysical Research* 80(36), 5069-5075 (1975). In 1938 Langmuir observed that floating seaweed is organized in lines on the water surface that are parallel with the wind direction. These lines are the result of wind-driven water circulation. Gammelsrød is considering both an inviscid and a viscous flow with a constant-velocity shear in the vertical in a neutrally buoyant fluid under the influence of the Coriolis force. He finds that the flow is unstable to roll vortices parallel to the flow. This instability results in the formation of circulation cells when the shear is of the order of the Coriolis parameter or larger.

Gammelsrød, Mork, and Dr. L. Roed have considered homogeneous ocean dynamics near an ice edge. The ice was modeled as a deformable floating boundary so that in the region covered with ice there cannot be a wind stress

on the sea surface while such a stress is acting in the ice-free portion of the model. Both time-dependent and steady-state models were considered. They found that the ice-edge could act as a coast and that upwelling could take place in the vertical plane passing through that edge. The vertical upwelling velocities were comparable with those obtained in the more conventional case [Gammelsrød, Mork and Roed, "Upwelling Possibilities at an Ice-Edge: Homogeneous Model," *Marine Science Communications* 1, No. 2, 115-145 (1975)].

In the third area of research, work is underway by Drs. L. Roed and M. Mäland to develop both numerical and theoretical models of wind-driven ocean circulation in the presence of sources and sinks of fluid at the boundaries. In numerical models of ocean circulations these sinks and sources model the inflow or outflow of water across boundaries. These models will be used in conjunction with atmospheric models being developed elsewhere under the Global Atmospheric Research Program (GARP) sponsorship. The ocean models should provide the heat flux at their upper boundary as a necessary input to the atmospheric models. Both Roed and Mäland are supported by research funds originating from the Norwegian Component of GARP; they are also interested in developing a numerical model that describes the circulation in the Barents Sea, for this circulation is also driven, in part, by sources and sinks. The dynamics are complicated by the presence of ice.

The fourth area of research deals with fjord and estuary dynamics. Professor H. Gade has been interested in these problems, and some of his students are working in this area. Recently he has been attracted by problems pertaining to Antarctica (see below) and has taken part in the January 1977 expedition to that continent. He feels that the fjord circulation is extremely dependent upon how one chooses the eddy coefficients of viscosity and of diffusivity. Most people have avoided the problem by adjusting these empirical constants to yield realistic solutions. He feels that at present Prof. R. Long's model [*J. Fluid Mech.* 71(3), 529-540 (1975)] is the best one available. Gade and a student have used such a model to generate solutions that are applicable to specific Norwegian fjords. Most of this work was presented at this year's Liège Hydrodynamic Symposium in Belgium (hosted by Prof. Nihoul's group) that dealt with the dynamics of fjords and estuaries. Gade feels that the oceanographical community has not yet recognized the virtues of Long's model, which works well in cases where the mixing in these fjords can be attributed to wind action rather than to internal waves.

Finally, the last area of research deals with both physical oceanography in the Antarctic region and the thermodynamics of seawater-and-ice mixtures. This program was started in 1968 when Mossby was interested in the formation of Antarctic bottom waters; it was decided to put current meters onto the shelf edge in the Weddell Sea. The Institute built four current meters, and Foldvik and Dr. T. Kvinge were part of a research team that, with the help of NSF funds and the USS GLACIER, placed them at depths in excess of 500 m so as to remain clear of large iceberg movements. These meters were designed to stay underwater for one year and to monitor the current as well as the temperature on an hourly basis. It wasn't until 1974 that, thanks to a US expedition in that same area and with further NSF support, two out of the four meters were recovered in perfect condition, with all the recording and sensing instruments absolutely dry. They yielded 9 and 15 months of data which show a marked decrease in the tidal current amplitude in July (winter of the Southern Hemisphere). Foldvik argues that in the winter months the water masses become saltier and more unstably stratified because of freezing. The situation leads to convection, which tends to mix the entire basin and render its density more homogeneous. As a result, tidal amplitude strongly decreases with depth when these nearly homogeneous conditions prevail.

In Decembe: 1976 the Norwegian government sent a research expedition to the Norwegian Sector of Antarctica on a small (500-ton) icebreaker; seismic, geological (bottom cores), biological, and physical oceanography of the Weddell Sea were the areas of research. In cooperation with Dr. T. Foster of the Scripps Institution of Oceanography in La Jolla, current meters as well as tidal gauges were put on the continental shelf of the Weddell Sea. Studies of the thermodynamics of sea water and ice were also undertaken [Foldvik

and Kvinge, "Conditional instability of sea water at the freezing point," *Deep Sea Research* 21, 169-174 (1974)]. In view of the importance of the location of the Bouvet Island for South African meteorological forecasts, scientists were sent ashore to set up an automatic weather station that is now transmitting temperature and wind speed. The data are being picked up by satellite and retransmitted to the US and Norway. This station is expected to last one year. Bouvet Island, according to Foldvik, is one of the most uninviting places on the globe with very severe storms almost all year round. In 1979 another Norwegian expedition will operate off Cape Town and will go to Bouvet Island in an attempt to establish a radiosonde station. This operation will provide data as part of the major GARP project entitled "First GARP Global Experiment" (FGGE) that will deal with the acquisition of meteorological data on a global basis. The station will be manned for two months during the Southern summer to obtain upper-air observations. The expedition will also retrieve the current meters placed in the Weddell Sea.

Although no longer news, a tragedy occurred in September 1976 in which the Institute's research ship, V/S HELLAND-HANSEN, went down about a day north of Bergen. The captain and one crew member were lost at sea, the casualties probably being caused by thermal shock. The Technical University of Trondheim is carrying out research to understand what happened to that ship. A model is now being tested to determine its stability characteristics under high waves and to assess the cause of this fatal accident. (Albert Barcilon)

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TECHNOLOGY

INTERACTIVE DESIGN SYSTEMS FOR BRITISH INDUSTRY(?)

As part of a major effort to upgrade the design and manufacturing technologies of British industry, the Department of Industry (DoI) sponsored a recent three-day meeting on the topic "Interactive Design Systems." The meeting was organized for the DoI by the Computer-Aided Design (CAD) Centre, Cambridge, which receives most of its financial support from DoI. (For a description of the research activities of the CAD Centre, see my article in *ESN* 31-4:141). The site of the conference was the Hilton Hotel in Stratford-upon-Avon.

The DoI's main objective in sponsoring this meeting was to promote the exchange of information between vendors of CAD and CAM (computer-aided manufacturing) systems and the actual or prospective industrial users of such systems. Quite correctly, the Department recognizes CAD and CAM as technologies which are now accessible to even small and medium-size firms, and that offer demonstrable cost savings and lead-time reductions over conventional, manual techniques. Reduced costs of hardware devices such as graphics display terminals, numerically controlled drafting machines, electronic data-input tablets, etc., and the commercial availability of the requisite computer software are the principal factors that have brought these technologies to fruition. The trend toward lower costs, the use of time-shared systems, and greater competition among more and more vendors is bound to continue for the next several years.

About 200 of the 270 conference participants represented British manufacturing organizations—the prospective user community. The remainder of the participants, aside from a few observers like me, represented companies that market hardware and software for interactive design systems. The non-British participants (17 Americans and 35 Europeans) were principally from among the latter group.

The conference was organized as follows. The first day, Wednesday, was devoted to presentations by persons representing system vendors. This group included L. Minardi of Applicon (US); E.M. Hoskins of Applied Research of Cambridge Ltd. (UK); E. Müller of the Institut für Konstruktionslehre (FRG); R. Badget of Computervision, Inc. (US); T. Lightburn of Davy Computing Ltd. (UK); J.R. Cookson of Ferranti Ltd. (UK); J. Taylor of Quest Automation Ltd. (UK); B. Upton of Racal-Redac Ltd. (UK); E. Hörbst of Siemens AG (FRG); N. Payne of Tektronix UK Ltd. (UK); L. Simon of United Computing Corp. (US); J. Madden of Isopipe Ltd. (UK); J.C. Snead, M.F. Hessey, and J.N.S. Deane of the Lucas Group Research Centre (UK); and P.J. Hanratty of Manufacturing and Consulting Services, Inc. (US).

Wednesday evening was devoted to a special two-hour panel discussion with contributed position papers on the topic "Design of an Engineering Database." Of the seven participants, four were American, two British, and one Norwegian.

The technical sessions on the second and third days were ostensibly reports of "user experience" with CAD and CAM systems. In fact, however, many of the seventeen presentations by users were simply testimonials, obviously orchestrated and directed by the vendor concerned, to the efficacy of particular systems. Such blatant collusion between vendor and customer raised the ire of the mostly-British audience, who felt that such tactics were not in keeping with the traditionally accepted British standards of fair play.

In addition to design systems for use by manufacturing industries such as electronics (printed-circuit-board layout systems) and automobile and aircraft (2- and 3-dimensional automated drafting systems), the conference also covered systems specifically tailored to the design needs of civil engineers, chemical engineers, and architects.

One particularly interesting new system for pipework-layout design was described by J. Maden (Managing Director of Isopipe, Ltd., UK). This system, called PDMS, is a graphically interactive, minicomputer-supported software system for the design of pipework layouts for complex chemical-processing plants such as oil refineries and power-generating stations, and for other applications such as pipework layouts in ships. The functional program modules within PDMS perform design, validation (e.g., checks for nonintersection and proper clearances), and drawing, and provide the man-machine communication interface. The data-management facilities of PDMS are such that plant and pipework designs of all sizes can be undertaken, including very large layouts involving 2,000 or more pipes. After a 45-minute personal demonstration, I walked away convinced that PDMS has virtually all the capabilities that a pipework designer would want in an interactive computer-based system. Originally developed by a group at the CAD Centre, the system is being marketed by Isopipe, Ltd. The first sale of PDMS was in March of this year to a Houston-based oil company, reportedly for $100,000.

Another seemingly very promising system for the CAD of chemical plants is the CPDS System described by E. Müller (Institut für Konstruktionslehre, Technische Universität Braunschweig). In his presentation, Müller made the point that it normally takes three years to construct a complex chemical plant after it is designed, and so the database that represents the plant and piping system must ensure the continued engineering validity of the data during all subsequent design modifications. Thus, such a computer-based design system increases the reliability of the plant layout as it evolves through the inevitable changes, as well as reducing the cost and lead-time of obtaining the initial design configuration.

Dr. A.G. Flutter, a consultant to the CAD Centre, spoke on the Centre's role in promoting the use of CAD in British industry. To illustrate how the basic software tools developed at Cambridge have been used as the foundation for more specialized industrial systems, Flutter considered three examples. One of these systems, developed for and in conjunction with the British firm Capper Neill International, is a drawing-office tool for the generation of design and fabrication drawings as well as a parts list and cost breakdown for liquid-storage-tank installations. This system is claimed to be twenty to sixty times cheaper than traditional procedures. A second example given was that of a special pattern-nesting and cutting system developed from CAD Centre software by Akermans, Ltd. The problem, which is common to all industries that cut

irregularly shaped patterns out of metal or textile rolls, is to position the patterns optimally on the roll so as to minimize waste. For a total software cost of less than $20,000, Akermans was able to develop a very cost-effective in-house capability for the nesting of sheet-metal parts and the generation of numerical control (NC) tapes for use in a flame cutting tool. The third of Flutter's examples was the adaptation of CAD Centre software by Precision Engineering, a Btitish tool and die manufacturer, to enable them to produce inspection drawings and NC milling tapes for complex forming dies. Again, the argument was made that the resulting computer-based system produced an "invaluable" saving in production lead-time.

The unavoidable conclusion to be drawn from this Department-of-Industry-sponsored conference is that there can no longer be any doubt as to the savings in labor costs and time that industries—both large and small—stand to gain by the introduction of the twin technologies of computer-aided design and computer-aided manufacturing. However, a question that none of the speakers addressed formally but that everyone discussed in the corridors is, "How can British industry introduce such technology without suffering serious labor disputes and possible (to use the quaint new British phrase) 'industrial action'? Industrial action, which means inaction (i.e., a strike), is the greatest fear of the industrial manager in Britain. For this reason alone, it seems unlikely that traditional design and manufacturing methodologies will soon be supplanted in the UK by the new, computer-based technologies. (William J. Gordon)

NEWS & NOTES

NORTH-SEA AND NORTH-ATLANTIC SATELLITE RESEARCH

The following announcement is quoted from a press release of the Council of Europe:

"A group of 40 scientists representing some 20 European laboratories met at the Institute of Oceanographic Sciences in Wormley, South England, last week to draft a program for exploiting data from sensors on board the forthcoming American remote-sensing satellite Seasat-A to be launched in May 1978. The group acts as a working group under the European Association of Remote-Sensing Laboratories, which is a cooperative body under the auspices of the Parliamentary Assembly of the Council of Europe with support from the Commission of European Communities and the European Space Agency.

"The program drafted is related to ongoing oceanographic research in the North Sea and the North Atlantic Ocean. In this, research data from the earth-directed sensors of the satellite will be employed to measure wave height, wavelength, surface temperature and salinity, and the wind speed at the sea surface. Comparison between satellite-derived quantities and actual measurements at the ocean surface will be made. Simultaneous measurements will be carried out from aircraft equipped with similar sensors.

"One of the satellite sensors permits measurements of the level of the ocean surface with an accuracy of 10 cm on the basis of very accurate tracking of the satellite's orbit from a network of special ground-based stations in Europe. This information will be used for geodetic studies and for investigations of tides and ocean swells.

"Another sensor—a special type of radar—will give mapping of the earth's surface in bands of 100-km width with a resolution of 25 m. Data from this radar will be used for observation of waves on the ocean, of sedimentation along the coasts of Europe, and for mapping of sea ice in the Gulf of Bothnia and the Greenland Sea.

"Apart from the oceanographic aspects, this research may be of importance for future applications such as ship-route selection, ocean navigation, and ship and coastal engineering. Because of their all-weather capability, similar sensors may be used in future operational systems for routing surveillance of all ocean activities including fisheries and off-shore oil exploitation, and will be important parts of meteorological and climatological forecasts."

FORTHCOMING MEETING

The Eleventh International Power Sources Symposium will be held at Brighton, England, 25-28 September 1978. About 40 papers will be presented, and, as far as possible, they will be grouped together in similar topics, such as primary, secondary, solar, and fuel cells; thermoelectric and thermionic generators; etc. The audience will be limited to 400 representatives of research and development work, application engineering, and user experience in the field of nonmechanical power sources. The Symposium is being arranged in association with the UK Joint Services Electrical Power Sources Committee.

Preprints of papers will be dispatched in advance of the Symposium to delegates who have paid the registration fee. The full texts of all papers together with the discussion will be published in book form. A copy will be sent without further cost to all delegates who have paid the registration fee. The deadline for submitting papers has already passed. The detailed program will be available early in 1978 from J. Thompson, Chairman, International Power Sources Symposium Committee, P.O. Box 17, Leatherhead, Surrey KT22 9QB, England.

ONRL NEWS

We welcome aboard the following scientists, who will be with us for periods between one and two years: Dr. Jack A. Adams, Professor of Psychology, University of Illinois (Psychology); Dr. Clifford C. Klick, Superintendent of the Material Sciences Division, Naval Research Laboratory (Physics); Dr. R.W. Rostron, Military Satellite Division, Defense Communications Agency (Space Physics); Dr. Irving M. Bernstein, Professor of Metallurgy and Material Sciences, Carnegie-Mellon Institute (Metallurgy and Material Sciences); and LCDR Stanley E. Sokol, Naval Sea Systems Command, Washington, DC (Weapons Systems).

We bade farewell to: Dr. John B. Bateman, who has retired in the United Kingdom; CDR Henry M. Jordan, who has retired from the Naval Service and now makes his home in Miami, Florida; and Dr. William G. Soper, who returned to the Naval Surface Weapons Center, Dahlgren, Virginia.

News was recently received of the death of Dr. F. Joachim Weyl, Dean of Science and Mathematics, Hunter College, New York. Dean Weyl was formerly a Liaison Scientist with ONRL (1951-52), and from 1961-66 he was Chief Scientist and Deputy Chief of Naval Research at ONR Headquarters.

PERSONAL

Dr. L.M. Hocking has been awarded the title of Professor of Mathematics in respect of his post at University College London. Mr. R. Mansell Prothero, Reader in the Department of Geography, University of Liverpool, has been awarded the title of Professor by the University. Dr. Robert Ramage, Senior Lecturer at the University of Liverpool, has been appointed to the Chair of Organic Chemistry at the University of Manchester Institute of Science & Technology (UMIST). Professor E.H. Rhoderick, Head of the Department of Electrical Engineering and Electronics, UMIST, will succeed Professor K.M. Entwistle as Dean for one year beginning 1 January 1978. Dr. J.M.T. Thompson has been awarded the title Professor of Structural Mechanics in respect of his post at University College, London.

OBITUARIES

Professor J.A.V. Butler, FRS, FRIC, Emeritus Professor of Physical Chemistry at the University of London, died 16 July at the age of 78. At the Chester Beatty Research Institute at the Royal Cancer Hospital, he and his team studied the fundamental aspects of the cancer problem, particularly the nature and function of the proteins in the cell nucleus. He was the author of *Chemical Thermodynamics*, *Science and Human Life*, *Inside the Living Cell*, and *Modern Biology and Its Human Implications*. In addition to his research work and writings, he was editor of *Progress in Biophysics and Molecular Biology*.

Professor G.N. Patchett, Professor of Electrical Engineering at the University of Bradford, died 19 July at the age of 60. He spent his academic life at Bradford, starting with the Bradford Institute of Technology, which later became the University. He was the first to institute the successful "sandwich" course at the degree level (alternating study and industrial work), which became the basic pattern

of undergraduate work at the University. Electronics and radio and television engineering were his special fields of interest. He wrote over thirty books and many professional journal articles.

Mr. R.T.P. Whipple, applied mathematician with the Atomic Energy Authority's Culham Laboratory, died in a climbing accident on 14 July. His major contributions to research were in the theory of fluid dynamics, the stability of plasmas in magnetic fields, wave propagation in magnetized plasma, centrifugal separation of uranium isotopes, and fast-reactor safety.

ONRL REPORTS

R-7-77 PRELIMINARY DESCRIPTION AND SPECIFICATIONS FOR A DANISH COASTAL MARINE DATA COLLECTION SYSTEM by J.P. Simpson

To an increasing extent Denmark is faced with a series of problems linked with the safe navigation of large and deep draft ships through the Danish waters. This is particularly important in the narrow and shallow fairways of the Baltic approaches where the waters have a transient nature because of their position between the fresh Baltic and the saline Kattegat. Instantaneous sea level, sea state, current, sound speed, ice probability and buoyancy are among the factors to be considered when navigating the Danish straits. The Royal Danish Administration of Navigation and Hydrography has undertaken the job of developing a system to measure or compute these parameters, providing "real-time" oceanographic data to transiting ships.

C-5-77 DIRECT SATELLITE BROADCASTING by N.M. Blachman

The Symposium on Direct Satellite Broadcasting (DSB), held in Dublin 23-25 May 1977, included 17 papers discussing the potentialities and problems of this new medium, which is to bring television to private homes via either 1-meter paraboloidal dishes or larger community antenna. This Symposium follows up the World Administrative Radio Conference of early 1977, which assigned frequencies for DSB in the 12-GHz band. Although intended primarily to rally support for DSB, the Symposium also included discussions of previous DSB work, planned experiments, technical specifications, cost comparisons, programming aspects, and legal difficulties, many of which remain to be resolved.

C-6-77 FIFTH INTERNATIONAL SYMPOSIUM ON MILITARY APPLICATIONS OF BLAST SIMULATION by W.G. Soper

A review is given of papers presented at the subject Symposium, which was held in Stockholm, Sweden, 23-26 May 1977. Principal emphasis in the review is placed on advances in shock tube design, new instrumentation, and the use of scale models in blast research. Several short shock-tubes driven by sources in parallel are described, and the success of cube-root scaling of magazine explosions and blast cratering is discussed.

C-8-77 COLLOQUIUM ON OPTICAL FIBER CABLE, INSTITUTION OF ELECTRICAL ENGINEERS (UK) by D.A. Hart

This report presents short summaries of papers presented at a colloquium on optical fibers held in London on 17 May 1977. Topics include propagation, cable manufacture, strength, testing, and installation of optical fiber cables.